EY

Infrastructure Compass 2024

October 2024

Building a better working world

Infrastructure Compass 2024

Infrastructure Compass is as an annual report aimed at analyzing the evolution and future of a sector as relevant as infrastructure. This first edition has been prepared by the Strategy and Transactions team at EY Spain based on data and information collected throughout 2023 and 2024.

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EY INSIGHTS

EY Insights aims to create and share knowledge that is useful to society as a whole. Our goal is to promote EY's participation in debates that are relevant to society, build bridges and disseminate content that helps companies, governments, and society at large to address current and future challenges, based on an approach that strives to create long-term value.

For further information

EY Insights
EY Insights is the knowledge hub responsible for creating and disseminating content for EY Spain.

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Introduction

Why we need a compass to advance in the field of infrastructure

Investment in infrastructure requires certainty, planning, and security. In today's dynamic global economy, managing these variables is challenging. However, understanding the scenario and obtaining detailed insights can improve decision-making. In economic activities, especially investments, risks are unavoidable, but these risks can be better managed with knowledge of market trends and reliable information.

To better understand where we are and where we are going in infrastructure investment, we launched the EY Infrastructure Compass. This EY initiative is designed to serve as a central hub and support mechanism for investors and industry professionals. It aims to provide critical insights into key sector issues, highlight essential data points, and outline strategic pathways for success.

For this first edition, under the title Fundraising: strategies and deployment, we have prepared an analysis of the global infrastructure market that gives us a broad vision of fundraising and other relevant topics, such as the strategies of Limited Partners and specialized funds. We also analyze recent major transactions and their outcomes to gain valuable insights into trends and developments in the coming months.

In this inaugural edition, we have included our EY Infrastructure Barometer. This analysis is based on a survey of over 80 professionals and experts in infrastructure investment in the Spanish context. The survey uncovers sector trends, preferences, and characteristics, identifying key factors for short-term strategic direction.

EY Infrastructure Compass aims to provide critical insights into key sector issues, highlight essential data points, and outline strategic pathways for success.

To provide a comprehensive perspective, we have included two in-depth analyses of emerging sectors that are attracting significant investor attention in Spain. In the chapter Data Centers Unveiled: Navigating the Spanish Landscape, we examine investment in Data Centers, a rapidly developing field with numerous emerging opportunities.

Along the same lines, we have analyzed the biogas investment sector, confirming its substantial potential and growing investor interest. In the chapter The Power of Feedstock: Fueling the Future with Biogas, we present compelling data on the immediate future of this emerging energy source.

In short, we have identified and analyzed data from key sector players to provide a compass that guides us and helps us move forward. This annual collaborative effort between EY and the industry will enhance our understanding and support the advancement of a sector as vital to the functioning of society as infrastructure financing.

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Summary

1. Global Trends Shaping Infrastructure Investment

1.1. Fundraising: Strategies and Deployment

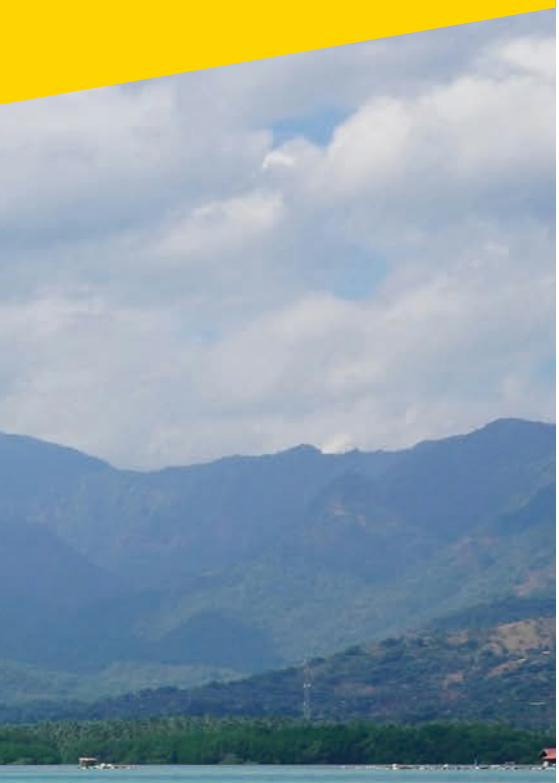
Rising Momentum

After sustained growth for over a decade, the infrastructure sector experienced a challenging year in 2023 after stringent monetary policies. Despite the market slowdown during the previous year, the ability of the infrastructure industry to hedge macroeconomic stress and high inflation levels once again positioned the asset class as one of the most attractive due to its resilience. Going into 2024, while high interest rates and an unclear macroeconomic outlook are still in the picture, the prospects for the asset class are more optimistic.

Infrastructure Fundraising

Prelude to Progress: Moving Past 2023's Hardships to a Hopeful 2024 in Infrastructure Fundraising

Over the years, the infrastructure sector has proven resilient, showcasing consistent growth despite global disruptions and economic uncertainties. This enduring strength was particularly evident as the sector weathered



the challenges posed by the global pandemic. Infrastructure fundraising experienced notable growth from 2020 to 2022, increasing by 45.5%. Despite this upward trajectory, infrastructure fundraising experienced a significant downturn in 2023, with global fundraising plummeting over 46% compared to 2022. This sharp reduction in fundraising activity was accompanied by a corresponding decline in the number of funds

$35.7bn

Looking ahead to 2024, the outlook is increasingly positive, with $35.7 bn of capital raised over the first quarter

actively seeking investment capital, dropping by 40%. Looking ahead to 2024, the outlook is increasingly positive, with $35.7 bn of capital raised over the first quarter of 2024, against $6.5 bn raised this same period in 2023.

The Big Picture: Macroeconomic Influences on the Infrastructure Investment Climate

In 2022, amid peak levels of infrastructure fundraising as the markets were enjoying stable and favorable performance, the first headwinds that would shape the infrastructure investment climate in the coming years started blowing. The joint effect of rising interest rates and the slowdown of investment activity due to the macroeconomic environment dealt a blow to 2023's fundraising activity. Looking into 2024, while the macroeconomic landscape points to complex scenarios, economic growth and inflation control could herald rate cuts to take place within the year.

Driving Progress: The Crucial Role of Debt Financing in Infrastructure Fundraising

Infrastructure debt exhibits one of the most rapid expansions out of all asset classes globally over the past decades, with Assets Under Management growing at a CAGR of 23% from 2015 until 2023. While fundraising dropped by over 45% in 2023, the performance of infrastructure debt fundraising was positive. The resilience of infrastructure debt highlighted its stability and appeal within the infrastructure fundraising landscape. Infrastructure debt accounted for almost 20% of all infrastructure funds raised in 2023, highlighting its role as the most in-demand strategy in the infrastructure sector. While rising rates drove the attractiveness and returns of infrastructure debt, the decreases in the Equity Risk Premiums derived from an underperformance of the global equity markets resulted in no significant growth in returns of equities in the infrastructure sector.

1.1. Fundraising: Strategies and Deployment

Adapting Strategies for LPs and Infrastructure Funds Amid Economic Shifts

Over time, LPs have consistently expanded their allocation to infrastructure funds driven by the attractiveness of infrastructure investments, which offer long-term, dependable returns that resonate with the investment goals of numerous investors.

LP Investment Strategies in High Risk-Free Rate Environments: Trends and Regional Preferences for 2023-2024

The main takeaways of LPs investment strategies are defined by the high risk-free rate environment which has characterized 2023, and which is expected to persist in early 2024. Infrastructure investors are looking for higher-return strategies, such as Value Add or Core Plus, with the intention of mitigating lower returns from Core strategies seeking higher total returns in their infrastructure investments.

Key Strategies Driving Infrastructure Funds Forward

- **Recycling Assets:** During the past year, when raising fresh capital was difficult, Infrastructure funds increasingly adopted a strategy of recycling assets that have achieved the desired rate of return.
- **Consolidation:** Amid slow fundraising and declining deal volumes, infrastructure funds turned to consolidation as a strategic imperative.
- **Management of Other Funds:** Infrastructure funds have been diversifying their investment offerings and expanding their market reach by managing other funds.
- **Strategic Partnerships:** Collaboration with strategic partners, such as development banks, government agencies, or other financial institutions, appeared as a key strategy utilized by infrastructure funds.

30.1%

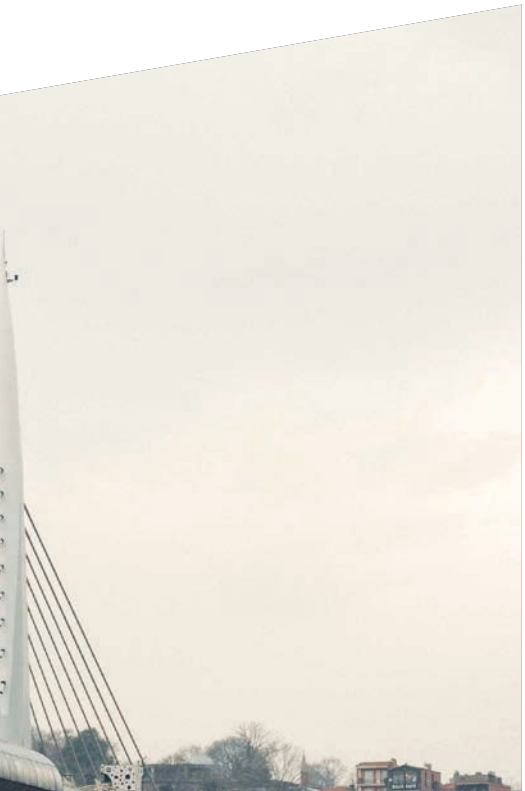
During the period from 2018 to 2023, the Telecommunications sector experienced the highest growth with a CAGR of 30.1%.

Infrastructure funds deployment

Closing the Gap: Overcoming Economic Hurdles and Valuation Challenges

Amid an uncertain economic landscape and high transaction costs due to high inflation rates, infrastructure deployment saw a significant decline in deal volumes. Compared to 2022, there was an 18% decrease in deal value, declining from $420 bn to $343 bn in 2023. Simultaneously, the number of deals dropped by 19%, falling from 2,665 to 2,151.

Looking into 2024, the valuation gap is expected to narrow as private market valuations adjust downward, resulting in an increase in transaction activity. The main driver pointing toward long term growth in the infrastructure sector is the global need for infrastructure investment.



Infrastructure Investment Landscapes: Global and Sectoral Overviews

From 2018 to 2023, infrastructure investment saw significant growth, driven by increased urbanization, technological advancements, and the need for modernization of aging infrastructure.

Regions: Prior to the Covid era, Asia was attracting the highest share of global investment, but was surpassed by Western Europe and North America, which have had the strongest performances in the post pandemic periods in terms of private infrastructure investments as a share of the Region's GDP growth. The Middle East is projected to lead with a CAGR of 11.9%, fueled by economic diversification, urbanization, mega projects, and strategic government initiatives. North America is expected to grow at 10.4%, driven by the need to renew aging infrastructure, technological integration, increased federal funding, and a focus on sustainability. In contrast, Australasia's growth is projected to be the slowest at 3.30%.

Sectors: During the period from 2018 to 2023, the Telecommunications sector experienced the highest growth with a CAGR of 30.1%. Natural Resources saw a 13.4% growth due to the need for sustainable resource extraction and fluctuating commodity prices. The Power & Utilities sector, growing at 10.0%, benefited from the global push toward renewable energy and decarbonization initiatives. Meanwhile, the social sector saw moderate growth of 4.3%, driven by increasing population needs and government investments in healthcare, education, and public facilities. The Transport sector lagged behind, with a minimal growth of 0.8%. Looking ahead to the period from 2023 to 2028, growth rates are expected to stabilize.

Capital Allocation Challenges in Infrastructure: Dry Powder and Investment Dynamics

The current landscape in infrastructure investment reveals a notable accumulation of dry powder, particularly concentrated in North America and Europe, due to the limited availability of bankable projects and high hurdle rates. This surplus of capital has created a dynamic where buyers are eager to secure favorable deals, while sellers exhibit hesitancy in parting with assets at significant discounts. Consequently, bid-ask spreads have widened as negotiation impasses persist.

1.1. Fundraising: Strategies and Deployment

Conclusions

- The infrastructure sector has consistently demonstrated resilience and growth, even amid global disruptions and economic uncertainties. The sector's ability to maintain stability has solidified its position as a sought-after asset class for investors seeking yield protection against market volatility.
- The fundraising landscape for infrastructure experienced a downturn in 2023 due to economic headwinds. Coming into 2024, the macroeconomic environment appears increasingly favorable for infrastructure investments. The positive capital raising in the first quarter of 2024 indicates a shift in investor sentiment.
- The accumulation of dry powder, especially in North America and Europe, presents both opportunities and challenges for capital allocation. Moreover, the enduring need for continued investment in infrastructure presents an ongoing opportunity for investors to realize the targeted benefits of private infrastructure.
- Debt financing within the infrastructure sector has shown remarkable growth, with infrastructure debt fundraising outperforming other strategies in 2023. In 2024, infrastructure debt is expected to continue offering attractive risk-adjusted returns, playing a crucial role in the sector's fundraising landscape.
- As a result of the long-term, high-yield environment, funds have favored investment strategies that satisfied their heightened return requirements. Core plus and value add strategies have surged in the past year and will likely continue to do so in the near future as the risk-return profiles are a best match for investor preferences in the current landscape.
- North America and Europe have emerged as preferred destinations for infrastructure investments in the post pandemic era, with growth within the transport and digital infrastructure sectors.
- Power and utilities continue to be the strongest sector within infrastructure investments, boosted by the global shift toward renewable energy sources. In the near term, digital infrastructure will likely be the driving force for infrastructure investments, especially in Europe.
- The infrastructure investment sector is poised for a resurgence in fundraising and deployment activities in 2024. The sector's inherent resilience, coupled with favorable macroeconomic indicators and strategic fund management, positions it for continued growth and success in the coming years. Investors can look forward to capitalizing on the opportunities that arise from a stabilizing economic environment and the ongoing need for infrastructure development globally.

1.2. EY Infrastructure Barometer

The EY Infrastructure Barometer gathers insights from a survey conducted among 80 senior executives, experts and professionals from large corporates, infrastructure investors, financial institutions, and private equity houses around the world. The survey's respondents, primarily from investment funds and corporates with significant asset portfolios and a global presence, have provided a comprehensive view of the current state and future expectations of the infrastructure sector in Spain.

Some of the key insights obtained from their answers were:

Investment Attraction
The Spanish infrastructure sector remains attractive to investors, with 80% having been active in the market over the last four years. The high quality of infrastructure and the potential in renewable energy and energy transition are key drivers of investment. Despite increasing competition, a significant number of investors plan to maintain or increase their deal activity in Spain.

Risks and Constraints
Regulatory uncertainty is the primary concern for investors, affecting the performance outlook and posing challenges for greenfield investments. Economic slowdown and administrative hurdles also contribute to the perceived risks.

Interest Rates and Market Dynamics
A moderate decrease in interest rates is anticipated by nearly half of investors, while the risk/return balance is viewed with moderate skepticism. Nonetheless, steady investment activity is expected to continue.

Portfolio Optimization
Investors prioritize organic growth and operational turnaround as the top strategies for enhancing investment performance, indicating a preference for internal development and efficiency improvements.

Technology Potential
While technology investments currently form part of the strategy for a minority of investors, there is recognition of the significant potential benefits of AI and analytics, particularly in the energy, transportation, and TMT sectors.

Data Centers and Biogas
There is reasonable interest in investing in data centers and biogas infrastructure. A subset of investors is actively considering these sectors for future investment in recognition of their role in advancing digitalization and decarbonization efforts.

Overall, the survey reflects a robust interest in the Spanish infrastructure sector, with a focus on sustainable growth, operational efficiency, and technological integration, despite the challenges posed by regulatory uncertainty and competitive pressures.

2.
Data Centers Unveiled: Navigating the Spanish Landscape

The exponential growth of global data traffic, propelled by burgeoning mobile usage and the pervasive influence of digitalization, cloud computing, over-the-top video, Internet of Things and artificial intelligence underscores the vast opportunities within the data landscape.

At the heart of the digital revolution are data centers, with recent trends indicating a significant shift toward cloud-based data storage and computing solutions. This underscores the growing importance of data centers as critical components of modern infrastructure.

In Europe, the leading data center markets are often denoted by the acronym FLAP-D, representing Frankfurt, London, Amsterdam, Paris, and Dublin. Despite their pivotal roles, other markets are emerging, such as Spain.

What are the main trends within the Spanish data centers market?

The data center industry in Spain is witnessing significant growth due to increased reliance on cloud computing and digital infrastructure. Major investments are flowing into cities like Madrid, driven by rising demand expected to surge further. Spain's commitment to renewable energy and the Digital Spain 2025 agenda are additional drivers of industry growth. Additionally, the rise in demand for managed cloud services is fueling investment in hyperscale data centers, which are a vigorously emerging subsector in Spain.

Growth in the Spanish Market

The global data center market is poised for substantial growth until 2031, fueled by advancement in AI, cloud computing, and evolving market demands. Spain emerges as a prominent player, and is expected to reach more than $600 million in colocation data center industry revenues by 2027.

Large Share of Hyperscale Data Centers

The appeal of the Spanish market for Cloud Service Providers (CSPs) is undeniable, with major Hyperscalers establishing or expanding their presence in Spain. Examples include Microsoft, which plans to develop a Cloud Region in Aragon with an expected investment of €6.69 billion over the next ten years; Google Cloud, which announced a new cloud region in Madrid, solidifying Spain's position in the global cloud landscape; Amazon Web Services (AWS), which launched its eighth European infrastructure region in Aragon with a $2.6 billion investment over the next decade; and Oracle, which opened its 40th global cloud region in Madrid in September 2022, marking Spain's first Oracle Cloud Infrastructure (OCI) region.

Renewable Energy Adoption
The data center industry is facing increasing pressure to prioritize sustainability, environmental friendliness, and energy efficiency, as it currently accounts for 2% of global greenhouse gas emissions. This necessitates proactive measures to reduce energy consumption, integrate renewable energy sources, and enhance cooling systems.

Artificial Intelligence to Drive Next Era of Demand Growth
Artificial Intelligence is a significant trend in Spain's data center market. Forecasts indicate Spain's AI market will surpass $10 billion by 2029, driven primarily by machine learning.

Emergence of Edge Computing Overcomes Latency Challenges
The rollout of 5G networks, which require high-speed, low-latency data transmission, is driving the need for new edge data centers in Spain.

Growing Interest in Liquid Cooling Technologies and Hyperconverged Infrastructure
Liquid cooling, an innovative method for managing heat generated by IT equipment using liquid-based solutions like water or specialized coolants, is emerging as a major trend in the data center industry.

2.
Data Centers Unveiled: Navigating the Spanish Landscape

What is the expected trajectory of the capacity of the Spanish data center market?

The data center industry in Spain is divided between retail and wholesale players, primarily serving metropolitan areas like Madrid and Barcelona, along with emerging hubs such as Bilbao. Wholesale operators dominate the market, with projections estimating over 1,800 MW of capacity by 2030. Retail operators, comprising around 80 facilities, provide customized services to smaller businesses.

Market Supply and Competitive Landscape

The data center market in Spain has undergone steady growth in recent years, fueled by the increasing demand for digital services, particularly cloud computing. Major players such as Equinix or Interxion offer a wide range of services, from colocation to managed hosting and cloud services.

Corporate Data Centers in Spain

The presence of corporations with data centers in Spain is concentrated among 14 Spanish firms that leverage their own data centers primarily as hubs for personal data. These companies collectively operate 38 data centers across Spain, predominantly in Madrid and Barcelona. Currently, corporate data centers in Spain have a total brownfield capacity of 204 MW, with 157 MW (80%) in use and 38 MW (20%) available.

What investment opportunities are available in the data center industry?

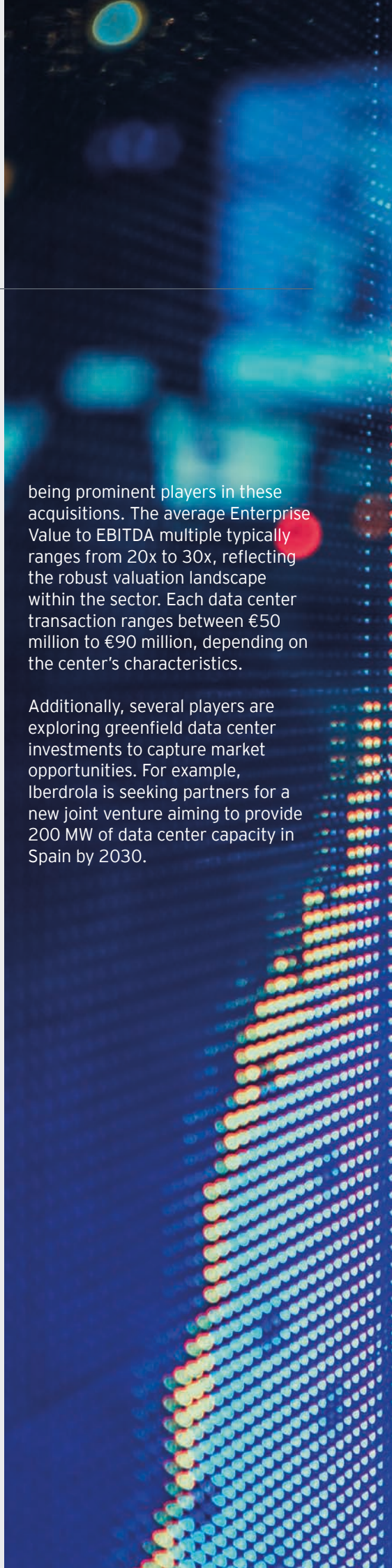
Spain's pivotal role in the expansion of the industry is underscored by increasing investment and a rising number of data center transactions, reflecting the growing importance of robust data infrastructure in the country's evolving digital landscape and its integration into the global business ecosystem.

Colocation demand in Spain is expected to surge significantly, driven by the expansion of cloud service providers, growth in content providers, telecom operators enhancing 5G capabilities, and limitations in primary European markets leading to shifts in workloads.

The colocation data center industry in Spain is set to experience significant revenue expansion, with revenues projected to escalate from $445 million in 2023 to $645 million by 2028, marking a noteworthy CAGR of 8%. Retail colocation dominates the market, accounting for 90% of revenues in 2023, with a projected CAGR of 4.34% from 2023 to 2028. Wholesale colocation revenues are anticipated to witness remarkable growth, with a CAGR of 27.42% until 2028.

In recent years, data center transactions in Spain have garnered significant attention, with notable deals involving technology companies focused on data centers as a service and private equity firms being prominent players in these acquisitions. The average Enterprise Value to EBITDA multiple typically ranges from 20x to 30x, reflecting the robust valuation landscape within the sector. Each data center transaction ranges between €50 million to €90 million, depending on the center's characteristics.

Additionally, several players are exploring greenfield data center investments to capture market opportunities. For example, Iberdrola is seeking partners for a new joint venture aiming to provide 200 MW of data center capacity in Spain by 2030.



3.
The Power of Feedstock: Fueling the Future with Biogas

Biomethane is one of the naturally occurring gases poised to play a prominent role in the decarbonization process currently underway in the European Union. The uses of biomethane encompass the same range as fossil-origin natural gas, including electricity generation, heat generation for industrial processes and end consumers, and as fuel for EV/GV transport vehicles. While both electricity generation and transportation have renewable alternatives, biomethane has high potential to establish itself as a differentiating asset for heat generation in hard-to-abate industries such as metallurgy, cement and chemical industries.

The compatibility of biomethane with Spain's developed gas infrastructure significantly increases its expansion possibilities within the territory. Spain has a gas pipeline network exceeding 11,000 km, along with numerous storage locations, making the country one of the best regions in Europe for the development of biomethane.

Analysis Goals

Considerations
There are several uncertainties or areas that require clarification in the biomethane sector. One is the availability of adequate and feasible feedstock in development regions, and the other concerns the expected market demand and the willingness of potential offtakers to pay. Additionally, a secondary objective of this analysis is to demonstrate that Spain's biomethane potential remains underutilized. The country's abundant raw materials and infrastructure readiness position Spain as a strategic generation hub at the European level.

Analysis Methodology
Three types of biomethane sources have been considered for this study: livestock, animal, and plant. To calculate the potential biomethane production in Spain, various feedstocks must be considered. This includes livestock waste, requiring an analysis of the number of livestock per province and the corresponding excrement production.

To extract energy from biogas in Spain, we focus on anaerobic digestion as the primary method. This commercially widespread technique is effective for producing biogas from easily degradable feedstocks, such as livestock waste, agri-food waste, and sewage sludge. Additionally, we look at gasification, a developing technology that converts waste that is difficult to degrade. These methods are essential for maximizing the energy potential from various types of waste.

Accessibility and Availability Coefficient
To estimate the potential of biogas generation in Spain, it is crucial to recognize that not all existing feedstock in the sector is accessible or available for use as fuel. Therefore, two coefficients have been utilized: the accessibility coefficient and the availability coefficient. The accessible potential refers to the amount of waste that could potentially be used for biogas generation without considering alternative uses. The available potential further reduces the accessible potential by accounting for alternative uses of the waste in each category.

95.91TWh

With accessible energy totaling 95.91 TWh, Spain exceeds the PNIEC's target of 20 TWh by 2030, demonstrating ample capacity to contribute significantly to renewable energy goals.

3.
The Power of Feedstock: Fueling the Future with Biogas

Outcomes of the Analysis

Overall Results and Key Figures on Potential, Accessibility and Availability

In terms of available energy Spain's significant potential in biomethane production aligns closely with the objectives outlined in the PNIEC (National Integrated Energy and Climate Plan) and IDAE (Institute for Energy Diversification and Saving). With accessible energy totaling 95.91 TWh, Spain exceeds the PNIEC's target of 20 TWh by 2030, demonstrating ample capacity to contribute significantly to renewable energy goals.

Furthermore, this aligns with the target set by IDAE in the "Hoja de Ruta del Biogás," which anticipated a range of 20 to 34 TWh for all types of waste. This study presents more optimistic figures due to its detailed analysis of the different types of waste with potential.

- More than 50% of accessible energy from animal sources is concentrated in 12 provinces.
- The top 5 provinces have accessible energy greater than 1.75 TWh and the top 7 provinces have accessible energy greater than 2.5 TWh.
- Around 50% of the accessible energy from plant sources is concentrated in 10 provinces.

Top 10 provinces and type of mix

The Spanish province with the most accessible energy is Lleida, with 5.29 TWh, accounting for 5.5% of the national total of 95.92 TWh. Lleida is notably distinguished by its accessible energy from animal sources, primarily derived from pig farming, which is significantly higher than that of other provinces in the top 10. This positions Lleida as a leader, given its animal-to-plant energy mix of 60% to 40%.

Top type of waste from animal and plant sources
Among the main types of plant waste contributing to accessible biomethane energy, two types stand out: straw and other crop residues (80%) and olive pomace and similar waste (17%). This concentration is significant for energy availability, as both types of waste are often repurposed for other uses that may command higher value than biomethane. As a result, the availability of energy from plant sources is reduced by 76%.

Biomethane efficiency and carbon footprint by source
Biomethane from plant sources generally exhibits higher efficiency compared to animal-based biomethane, due to the composition and availability of the raw materials. Energy crops such as maize, beet, and sorghum, which are rich in carbohydrates, cellulose, and hemicellulose, are efficiently converted into biomethane through anaerobic digestion. On average, biomethane from vegetable sources can produce 1.99-2.98 MWh per ton of plant-based biomass, while biomethane from animal sources yields 0.20-0.79 MWh per ton of animal manure.

Conclusions

Biomethane, given its potential to replace fossil fuels, is a key element for the EU's 2050 climate goals. It is particularly valuable for heat generation in hard-to-abate industries, where electrification solutions are not enough, such as metallurgy, glass, or cement. Spain's extensive gas infrastructure and large agricultural sector make it ideal for biomethane development. Additionally, biomethane reduces carbon dioxide emissions by reusing waste, offering economic and employment benefits.

Overall Potential
Spain has significant potential to develop its biomethane industry, with accessible energy levels far surpassing the 2030 PNIEC and IDAE targets.

Strategic Provinces
It will be critical to focus on provinces with high potential and a balanced mix of animal and plant waste for optimal biomethane production.

Challenges
Addressing the competition for plant waste and improving the collection and utilization efficiency of animal waste can help maximize available energy across the country.

Other considerations
Plant-based biomethane typically achieves higher efficiency due to energy crops' rich carbohydrate content. In contrast, animal-based biomethane, sourced from lower-energy manure, varies in efficiency due to its composition and inconsistent digestibility.

1 Global Trends Shaping Infrastructure Investment

1.1. Fundraising: Strategies and Deployment

Rising Momentum

After more than a decade of sustained growth, the infrastructure sector faced a challenging year in 2023 due to stringent monetary policies. The rise in interest rates, which reduced equity risk premia, coupled with wide bid-ask spreads, led to a decline in both fundraising and deal activity. Despite the market slowdown, infrastructure's capacity to withstand macroeconomic stress and high inflation levels reaffirmed its position as one of the most attractive asset classes due to its resilience.

Going into 2024, while high interest rates and an unclear macroeconomic outlook are still in the picture, the prospects for the asset class are more optimistic. The gap created in valuations in 2023 is expected to narrow in the near term, prompting market consensus to lean toward an increase in transaction activity. Furthermore, the growing need for capital to develop infrastructure globally will drive fundraising levels upwards.

Through this report, we analyze the macroeconomic environment, delve into fundraising and investment currents and explore sector and geographic trends.

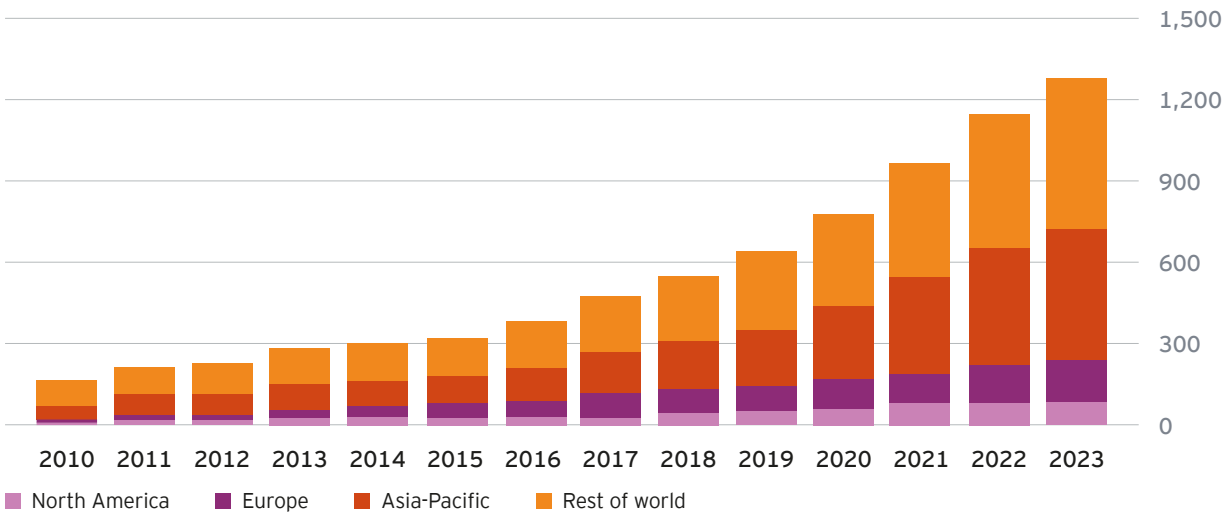
Infrastructure Fundraising

Prelude to Progress: Moving Past 2023's Hardships to a Hopeful 2024 in Infrastructure Fundraising

Over the years, the infrastructure sector has proven resilient, showcasing consistent growth despite global disruptions and economic uncertainties. This enduring strength was particularly evident as the sector weathered the challenges posed by the global pandemic and other macroeconomic pressures that surfaced in the past few years. While past market shocks have impacted returns across all equity classes, unlisted infrastructure has demonstrated significantly greater stability compared to global equities.

For well over a decade, infrastructure has surged as an asset class, with assets under management surpassing $1,000 bn in 2023, almost seven times the level in 2010, as investors seek yield protection against market volatility.

Figure 1 **Assets Under Management by Region** ($ bn)



Source: Preqin. Data as of June, 2023.

Figure 2 **Annualized Returns by Type of Equity** (%)[1]

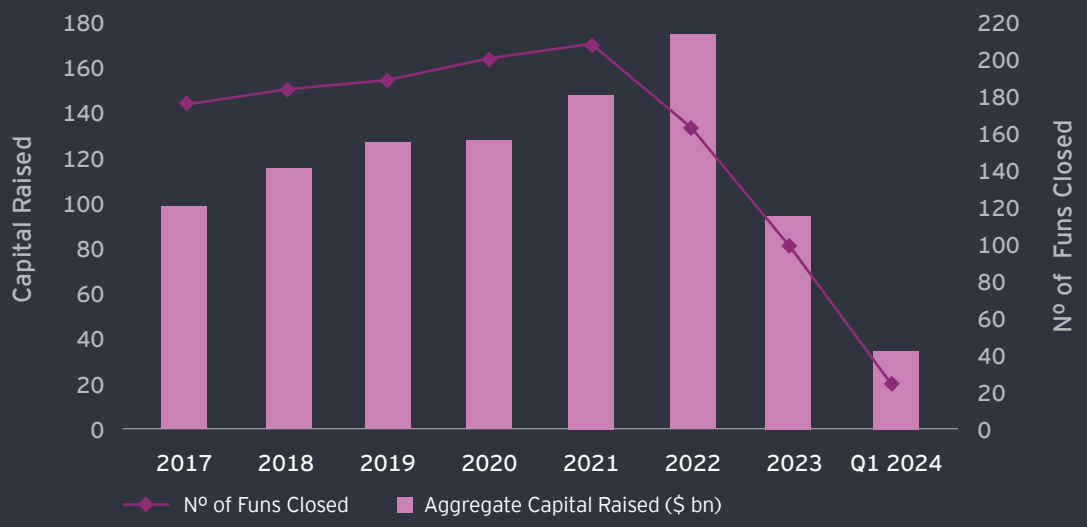
Source: MSC and EDHEC Infra. Data as of September, 2023.

[1] Annual returns based on monthly gross returns in a calendar year. Global equity performance measured by the MSCI All Country World Index (MSCI ACWI). Unlisted infrastructure equity performance is measured by the EDHECInfra Infra300 equity index. Green unlisted infrastructure performance is measured by the EDHECInfra InfraGreen Index.

Infrastructure fundraising experienced notable growth from 2020 to 2022, increasing by 45.5%. This surge can be attributed to several key drivers, including heightened investor interest in long-term stable assets, favorable regulatory environments supporting infrastructure development, and increased government spending on infrastructure projects.

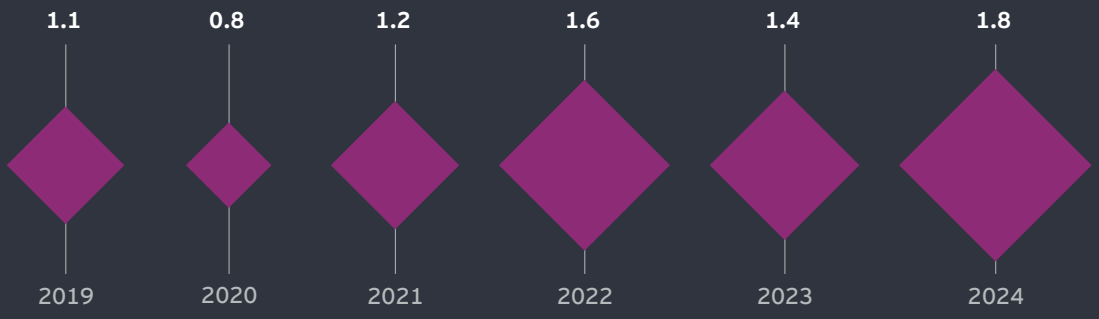
Despite this upward trajectory, infrastructure fundraising experienced a significant downturn in 2023, with global fundraising plummeting over 46% compared to 2022. This sharp reduction in fundraising activity was accompanied by a corresponding decline in the number of funds actively seeking investment capital, dropping by 40%, mainly as a result of rising interest rates and an economic slowdown, which made capital both more expensive and scarcer. As interest rates rose during the year at a higher pace than the return of equity markets, equity risk premia declined for most asset classes, impacting the relative attractiveness of equity infrastructure investments, thus affecting fundraising.

Figure 3 **Global Infrastructure Fundraising**

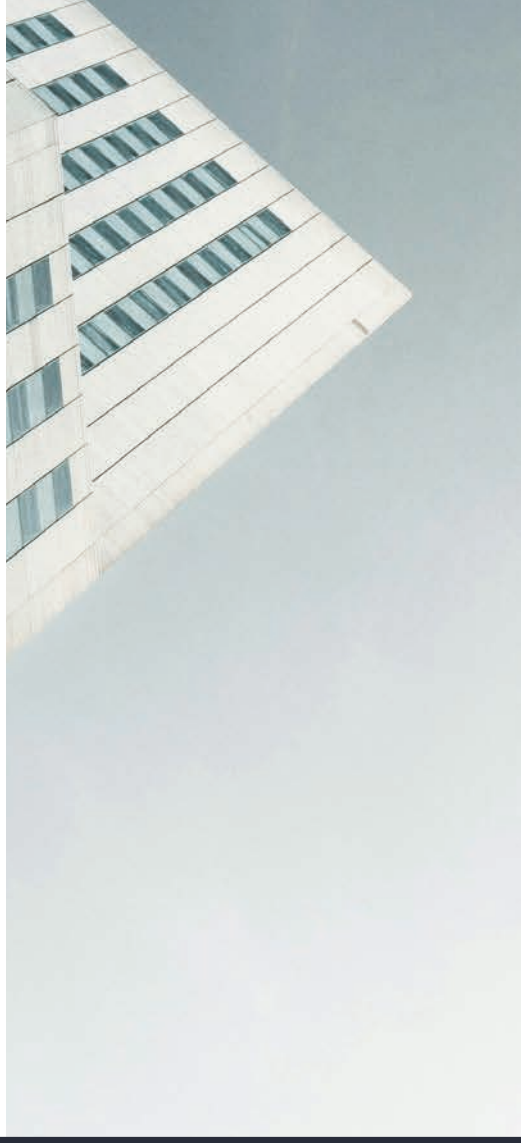


Source: Preqin. Data as of April, 2024.

Figure 4 **Average Fund Size ($ bn)**



Source: Infrastructure Investor.



The slowdown in exits, resulting from delays in returning capital to investors amid an economic downswing, also significantly contributed to the sluggish fundraising environment. These delayed exits impacted investor willingness to commit to new funds, initiating a ripple effect of uncertainty and hesitancy across the fundraising ecosystem.

Looking ahead to 2024, the outlook is increasingly positive, with $35.7 bn of capital raised over the first quarter of 2024, against $6.5 bn raised this same period in 2023.

Additionally, average fund size resumes its upwards trajectory. These indicators could suggest a change in investor sentiment, leaving behind concerns over heightened interest rates on the sector's asset values and fundraising activities.

The year 2023 was characterized as a year of high rates, geopolitical tensions, and high inflation rates. Going into 2024, high interest rates are again high among investors' main concerns regarding their infrastructure investments. The upcoming year will be predictably surrounded by a complex geopolitical landscape as well, while inflation rates are below 2022-peaks but still higher than most central banks' targets.

Figure 5 **Challenges for Returns** (% of respondents)

Source: Preqin. Data as of December, 2023.

41%

According to Preqin, 41% of investors surveyed plan to commit more capital to private infrastructure in the next 12 months.

Even if the market is still on the lookout for high interest rates, going into 2024 investors are confident that yields have reached their peak, leading to an optimistic view of stable interest and inflation rates in the near future. According to Preqin, 41% of investors surveyed plan to commit more capital to private infrastructure in the next 12 months, a slight improvement from the 35% reported in the 1H23 survey published in March. This indicates that fundraising could see an uptick in 2024.

The influx of capital experienced in the first quarter of 2024 suggests diminishing concerns about the impact of heightened interest rates on the value of infrastructure assets and the level of deal activity within the sector. Investors appear to be regaining confidence, recognizing the inherent resilience and long-term value of unlisted infrastructure investments.

The Big Picture: Macroeconomic Influences on the Infrastructure Investment Climate

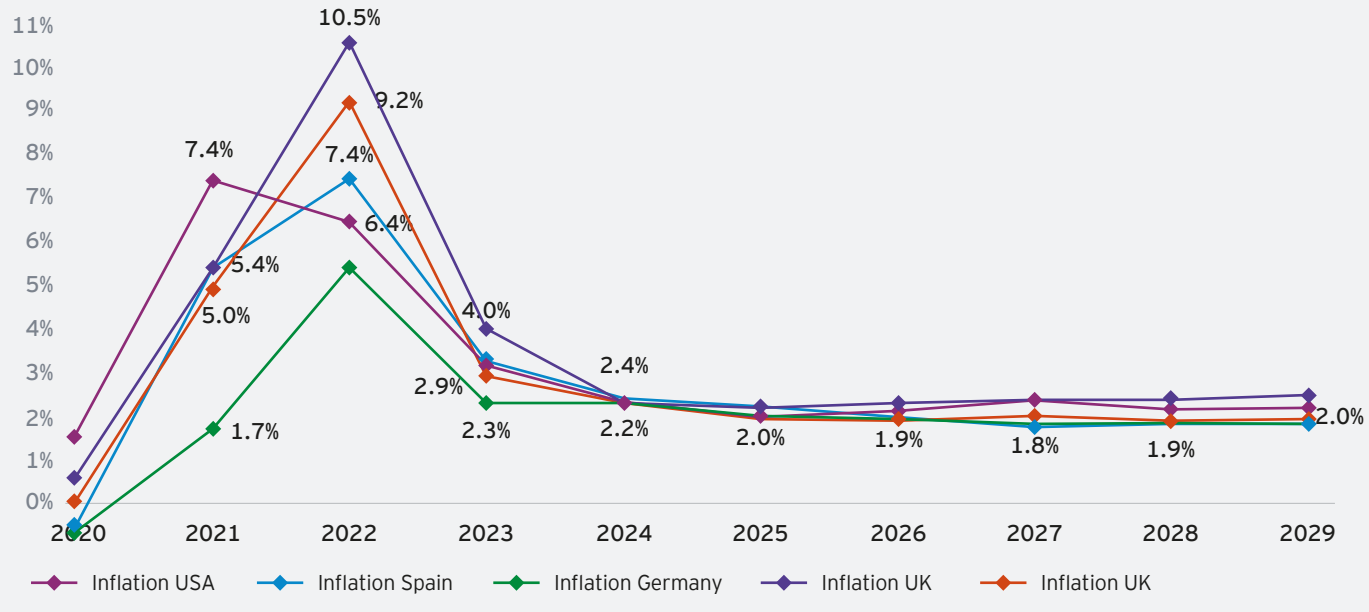
In 2022, amid peak levels of infrastructure fundraising as the markets were enjoying stable and favorable performance, the first headwinds that would shape the infrastructure investment climate in the coming years started blowing.

Sharp rises in inflation levels led central banks to implement contractionary monetary policies by aggressively increasing interest rates to control inflationary pressures and stabilize the economy. The joint effect of rising interest rates and the slowdown of investment activity due to the macroeconomic environment dealt a blow to 2023's fundraising activity. Looking into 2024, while the macroeconomic landscape points to complex scenarios, economic growth and inflation control could indicate rate cuts to take place within the year.

In the current context, inflation rates have decreased and are currently at levels below 2022 peaks, but central banks are struggling to perform last mile disinflation. Nonetheless, inflation levels are expected to stabilize at around 2% from 2025 onward, achieving most of the central banks' targets.

Moving into 2024, macroeconomic indicators support market outlooks for stable performance and potentially stronger fundraising activity. Analyst projections suggest a decrease in inflationary pressures, prompting central banks to consider reducing interest rates and lowering bond yields in line with inflation forecasts. This shift towards lower interest rates is anticipated to create a conducive atmosphere for infrastructure investment, as the cost of capital decreases, thereby potentially stimulating fundraising activity.

Figure 6 **Inflation Forecast, Annual Growth Rate** (%)



Source: EY analysis based on IMF and Oxford Economics.

The anticipated decline in bond yields is expected to lower financing costs, making borrowing cheaper and enhancing the viability of investment projects. This is likely to stimulate economic growth by encouraging increased investment activity and expanding capital availability. With governments worldwide implementing policies and initiatives to promote investment in renewable energy and digital infrastructure, these sectors are expected to attract investor interest and capital inflows in 2024 and future years.

Driving Progress: Debt Financing's Crucial Role in Infrastructure Fundraising

Infrastructure debt exhibits one of the most rapid expansions out of all asset classes globally over the past decades, with assets under management growing at a CAGR of 23% from 2015 until 2023. The low demand elasticity and high entry barriers of infrastructure assets, which in turn provide predictable, stable and reliable cash flows, allow for lenders to diversify their portfolios, and benefit from growing risk-adjusted returns.

While fundraising dropped by over 45% in 2023, the performance of infrastructure debt fundraising was positive. Rising base rates and spreads increased the relative attractiveness of infrastructure debt, especially compared to core infrastructure equity strategies on a risk-adjusted return basis.

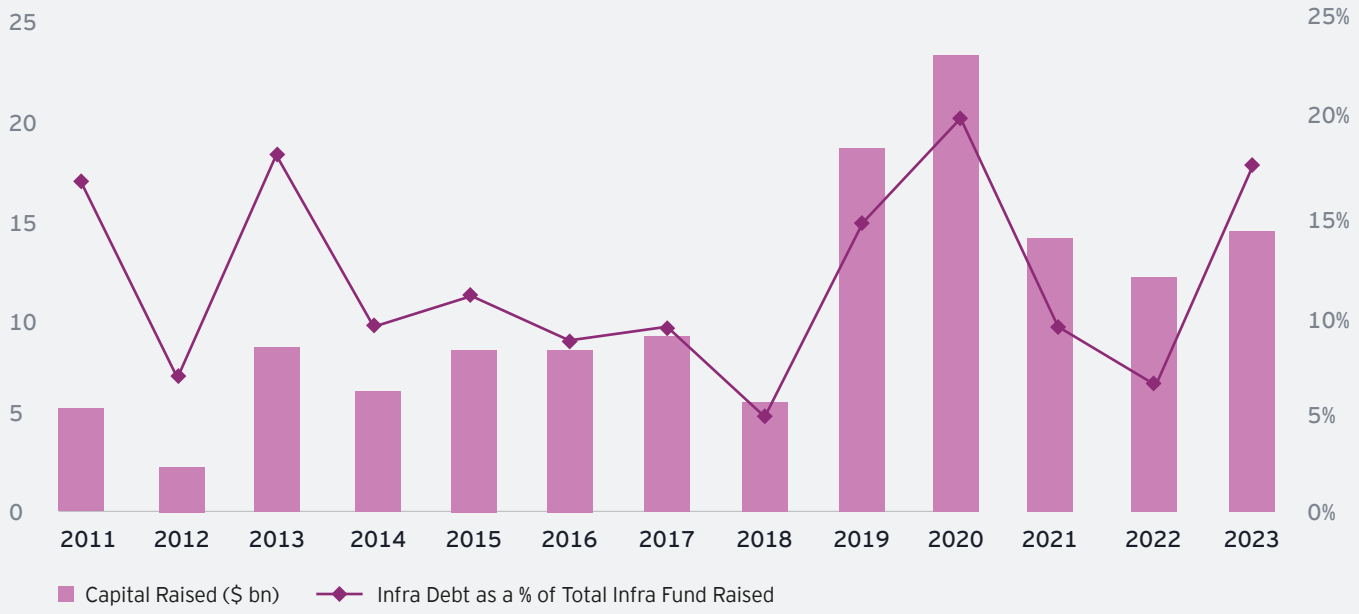
The resilience of infrastructure debt highlighted its stability and appeal within the infrastructure fundraising landscape. Rising rates through the past year increased the relative attractiveness of infrastructure debt compared to equity investments in the sector. Looking to 2024, infrastructure debt will continue to play on high interest rates, again offering attractive risk-adjusted returns.

Infrastructure debt accounted for almost 20% of all infrastructure funds raised in 2023, highlighting its role as the most in-demand strategy in the infrastructure sector. As of June 2024, infrastructure debt accounts for almost 25% of infrastructure funds raised.

23%

Infrastructure debt exhibits one of the most rapid expansions out of all asset classes globally over the past decades, with assets under management growing at a CAGR of 23% from 2015 until 2023.

Figure 7 **Infrastructure Debt Fundraising**



Source: Inframation. Data as of January, 2024.

> Evolving Equity Returns: A Closer Look at Risk-Free Rates and ERP Adjustments

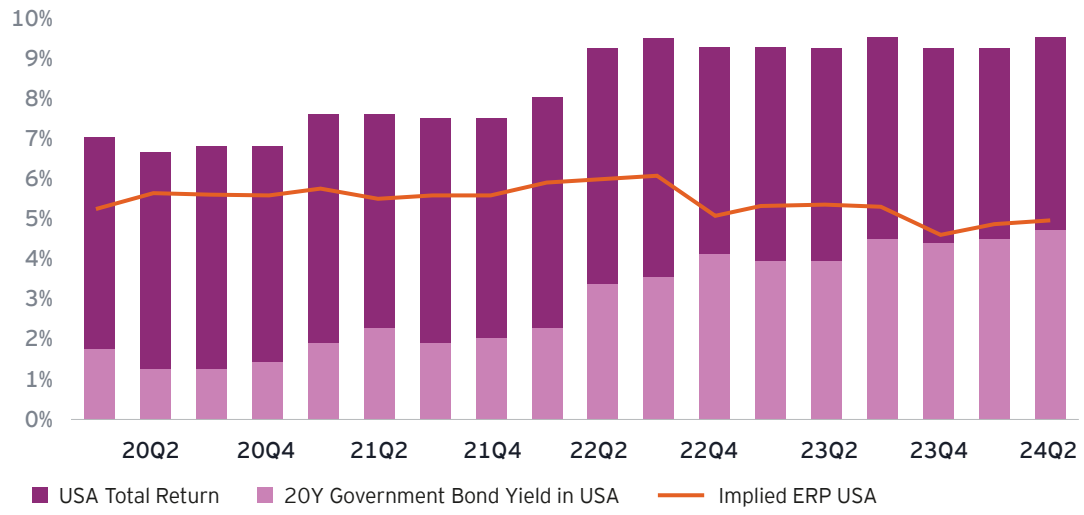
While rising rates drove the attractiveness and returns of infrastructure debt, the decreases in equity risk premia triggered by underperformance of global equity markets resulted in no significant growth in returns on infrastructure equities.

Figure 8 **Total Return Breakdown by Geography** (%)

Total required return by global equities investors experienced a slight increase in 2022 and remains constant since then, as the challenges posed by the uncertainty in the macroeconomic environment shape investor preferences. Long-term government bond yields, which are often taken as a reference for the calculation of the risk-free rate, have continued to experience a constant rise since 2022, although more attenuated than those of the previous year.

In terms of total required risk return, the increase in the risk-free rate is offset by a decrease in the Equity Risk Premium (ERP), which reflects the premium required to invest in equities listed on major stock indexes. This dynamic is driving a general rise in stock markets since the end of 2023, primarily fueled by increases in technology company stock prices.

While risk premia and required returns remained relatively stable in 2023, the prospects for investors to achieve significant returns on their equity investments in the infrastructure sector were limited. Market conditions did not provide ample opportunities for investors to fully capitalize on their infrastructure equity holdings as they might have anticipated.



Source: EY analysis based on Capital IQ and Bloomberg.

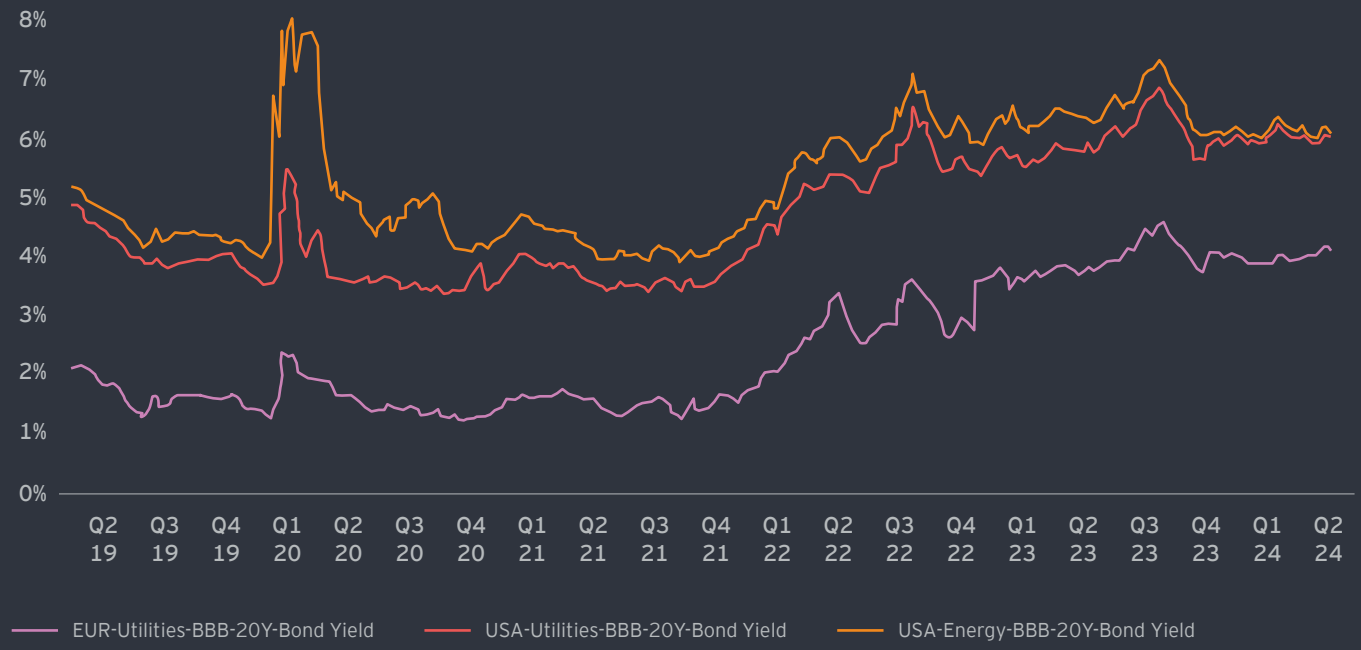
* Europe has been calculated as the weighted average of Germany, UK, France, Italy and Spain, which represent a proxy of 60% of total European GDP.

> Debt Attractiveness in the Face of Increasing Interest Rates and Inflation Challenges

With the rise of interest rates, the cost of borrowing increased, impacting the yields on debt securities through an upward pressure aiming to compensate investors for the heightened risk associated with lending in a higher-rate environment. However, last mile inflation is becoming harder to beat, thus impacting longer-term high yields.

Rising debt spreads made infrastructure debt increasingly appealing to investors when compared to higher-risk equity strategies presenting higher yield potential, along with reduced relative risk, capital preservation characteristics, and stable returns. Looking into 2024, analysts point toward growth in the demand for riskier equity strategies in infrastructure, while infrastructure debt will maintain its popularity among investors.

Figure 9 **Utilities and Energy BBB Bond Yield by Geography (%)**



Source: EY analysis based on IMF and Oxford Economics.

Adapting Strategies for LPs and Infrastructure Funds Amid Economic Shifts

Over time, LPs have consistently expanded their allocation to infrastructure funds driven by the attractiveness of infrastructure investments, which offer long-term, dependable returns that resonate with the investment goals of numerous investors.

Infrastructure funds have continued to lead the charge in real asset fundraising since 2016, and the trend persists going into 2024. In the first quarter of the year, infrastructure funds represented a commanding 95.5% of the total capital raised for real assets.

> LP Investment Strategies in High Risk-Free Rate Environments: Trends and Regional Preferences for 2023-2024

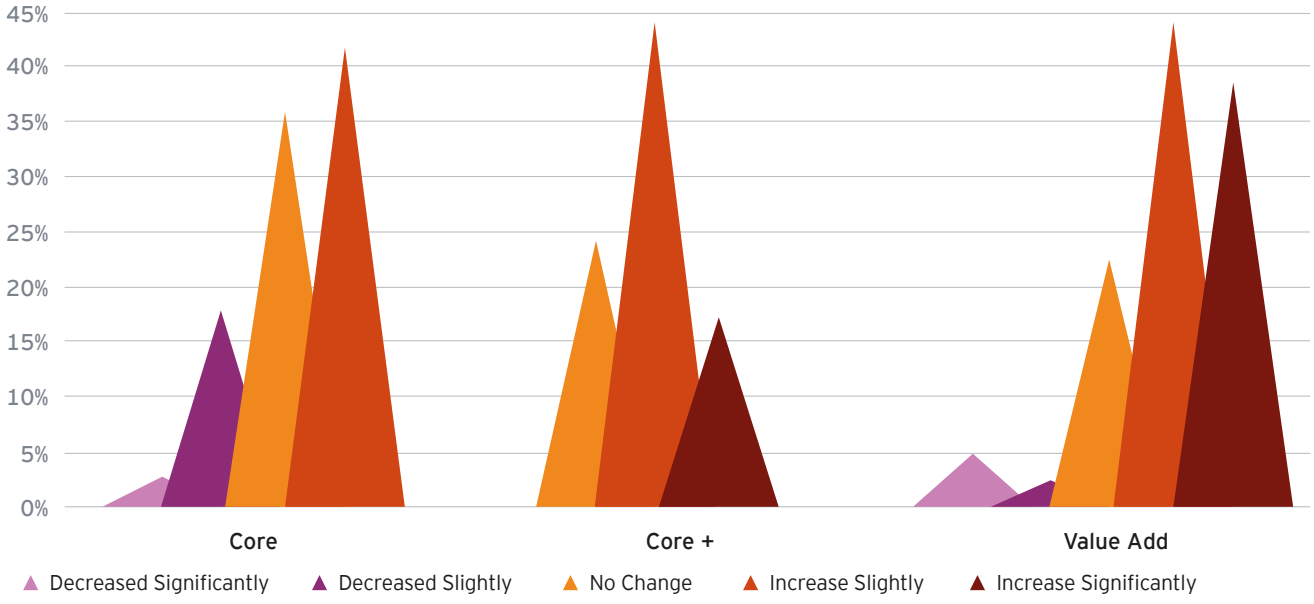
The key takeaways from LP investment strategies in 2023, marked by a high risk-free rate environment expected to continue into early 2024, highlight a shift towards higher-return strategies. Infrastructure investors are increasingly favoring Value Add or Core Plus strategies to offset the lower returns from Core strategies and seek higher overall returns.

Current investors in Core assets are encountering reduced market returns, prompting a move towards riskier strategies, such as Core + or Value Add, to enhance portfolio performance.

In addition to their traditional role as equity providers, LPs are increasingly stepping in as alternative lenders. Traditional banks have retreated from long-term infrastructure financing due to balance sheet constraints and regulatory pressures, creating significant opportunities in this sector. This shift is particularly appealing to investors seeking diversification and risk mitigation.

When it comes to regional preferences, North American fund managers and their access to regional alternative assets are expected to attract the majority of LPs' capital allocations over the next 12 months. Over half of LPs in the 2023 LP Survey (56%) indicate a preference for North America when considering the allocations they are due to make in the coming year. Over a quarter (27%) plan to allocate to managers in the UK and Europe.

Figure 10 **Relative focus of infrastructure fundraising by asset type** (2024 vs. 2023, % of respondents)



Source: Roland Berger Infrastructure Investment Outlook Survey 2024.

> Key Strategies Driving Infrastructure Funds Forward

Recycling Assets

During the past year, when raising fresh capital was difficult, infrastructure funds increasingly adopted a strategy of recycling assets that have achieved the desired rate of return. By reallocating resources from mature assets to pursue investments in early-stage development projects, funds were able to capture higher rates of return and maximize their investment portfolios' growth potential, allowing funds to optimize their capital deployment and maintain a dynamic investment pipeline.

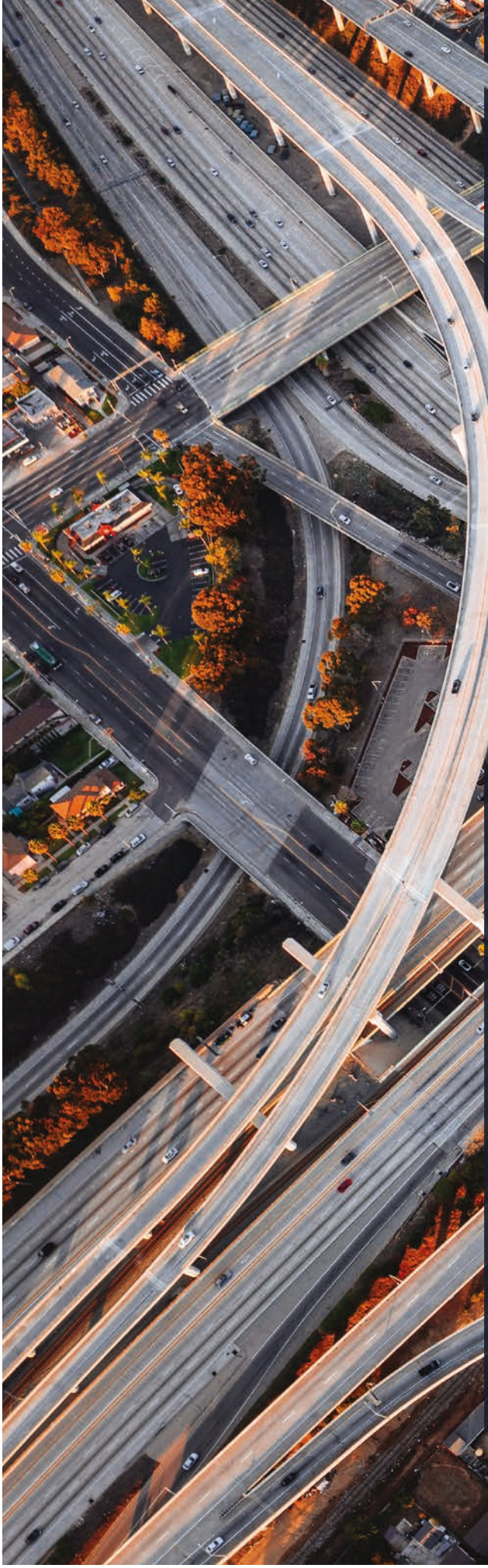
In the first half of 2023, Brookfield Infrastructure Fund IV divested its 49.5% ownership in Vodafone New Zealand to Infratil, and KKR Infrastructure sold 5% of its stake in Vantage Tower to UniSuper for $614 mn.

Consolidation

Amid slow fundraising and declining deal volumes, infrastructure funds turned to consolidation as a strategic imperative. By merging with or acquiring other entities, funds gained economies of scale, enhanced operational efficiency, and entered new markets more effectively. Consolidation enabled funds to strengthen their competitive position in the infrastructure investment sector and attract larger pools of capital.

This can enhance fundraising efforts by presenting a more organized and efficient investment opportunity to potential backers. Mergers and acquisitions among infrastructure companies helped streamline operations and reduce costs, making it easier to raise funds for new projects.

In early 2024, BlackRock acquired Global Infrastructure Partners for $12.5 bn with an aim to deliver holistic infrastructure expertise with GIP's $100 bn AUM and BlackRock's $50 bn infrastructure platform. Months before, CVC Capital Partners bought a majority stake in DIF Capital Partners with $1 bn in cash and stock.



Management of Other Funds

Infrastructure funds have been diversifying their investment offerings and expanding their market reach by managing other funds. By offering a broader range of investment vehicles tailored to different investor preferences and risk profiles, funds attracted a more diverse investor base and optimized their revenue streams. This strategy enhanced the overall profitability of the infrastructure fund management business and reinforced the fund's position as a trusted partner in the investment community.

Infrastructure investment managers diversified their portfolios and optimized fund allocations, enhancing their ability to attract and secure investments. In the first quarter of 2024, APG expanded its third-party infrastructure fund management activities, joining forces with Japan's Government Pension Investment Fund to invest in the sector. Notably, at the end of 2023 Brookfield Asset Management (BAM) and ALTÉRRA announced the creation of a multi-bn dollar Catalytic Transition Fund (CTF) to be overseen by Brookfield.

Strategic Partnerships

Collaboration with strategic partners, such as development banks, government agencies, or other financial institutions, emerged as a key strategy employed by infrastructure funds. Strategic partnerships provided funds with additional avenues for capital deployment, diversification, and risk mitigation, thereby strengthening their position in the competitive landscape of infrastructure investment.

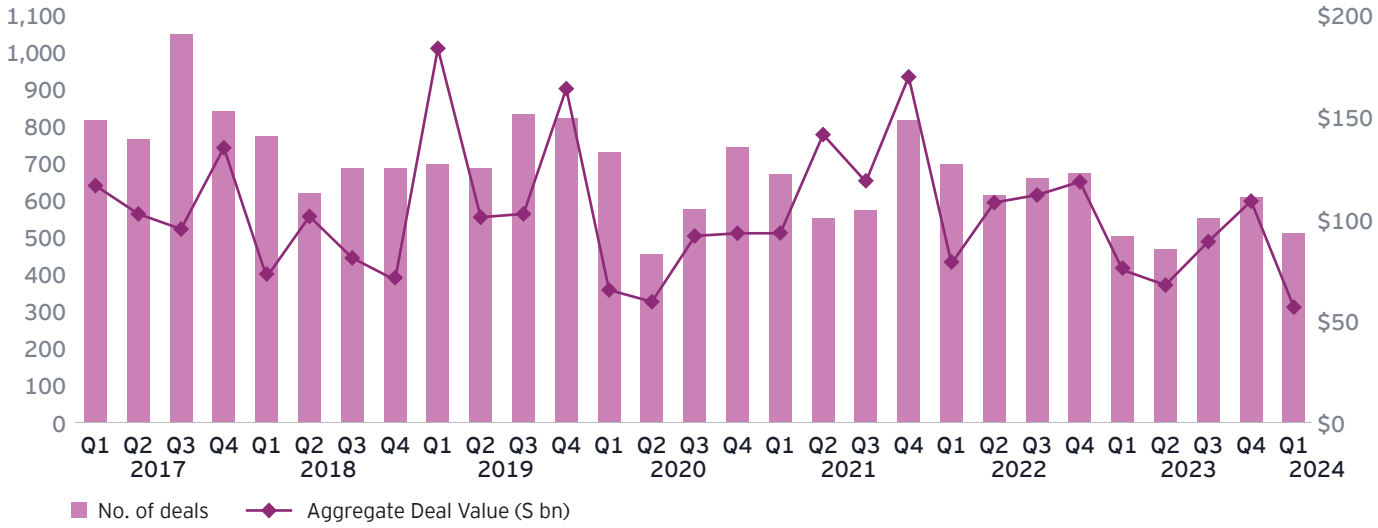
Collaborations between public and private sectors, as well as international partnerships, provided additional funding sources and expertise, boosting infrastructure projects.

In this connection, the European Investment Bank has provided $40 mn to Acre Impact Capital's Export Finance Fund I, an Africa-focused infrastructure debt fund which invests in climate-aligned infrastructure. Additionally, SUSI Partners' Asia Energy Transition Fund raised USD 120m from seven DFIs including Asian Infrastructure Investment Bank, Dutch FMO and Nordic DFIs Norfund and Swedfund.

Infrastructure Funds Deployment

Closing the Gap: Overcoming Economic Hurdles and Valuation Challenges

Figure 11 **Private Infrastructure Transaction Activity**



Source: Preqin. Data as of April, 2023.

Amid an uncertain economic landscape and high transaction costs due to high inflation rates, infrastructure deployment saw a significant decline in deal volumes. Compared to 2022, there was an 18% decrease in deal value, declining from $420 bn to $343 bn in 2023. Simultaneously, the number of deals dropped by 19%, falling from 2,665 to 2,151.

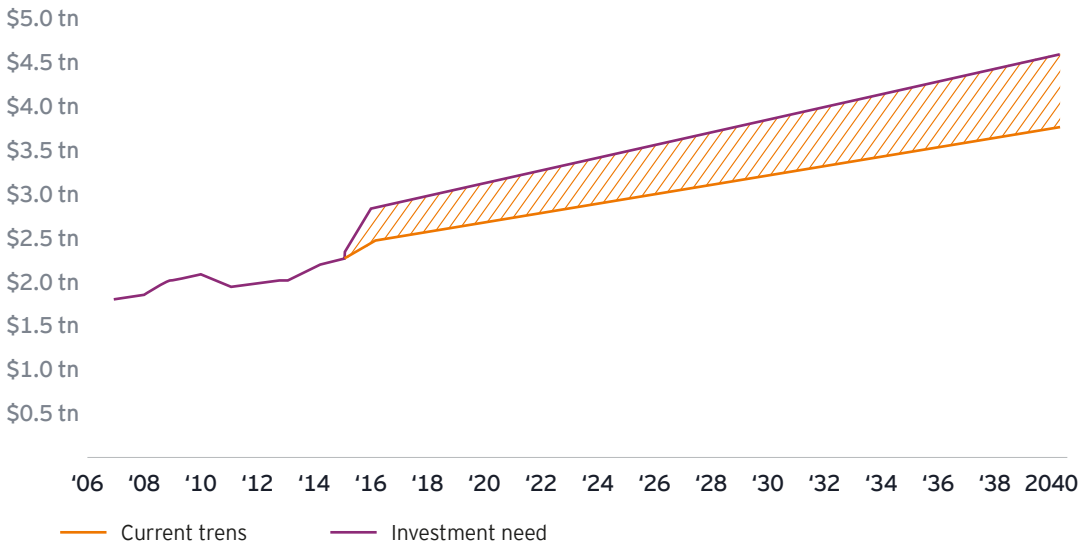
A significant factor contributing to this downturn is the disparity in valuation viewpoints between buyers and sellers, resulting in a widening bid-ask spread. Despite this, the resilient fundamentals of private infrastructure have empowered sellers to exercise patience in negotiations, even if it entails a temporary halt in dealmaking.

As interest rates surged, the cost of financing infrastructure projects increased as a knock-on effect, posing additional challenges to deployment efforts. With less capital raised for infrastructure projects, there was a limited pool of funds available for investment. This scarcity of capital can make it more challenging for project developers to secure financing and deploy capital on projects and subsequent transactions.

Looking into 2024, the valuation gap is expected to narrow as private market valuations adjust downward, resulting in an increase in transaction activity. In the context of economic uncertainty and high interest rates, infrastructure assets which enjoy numerous regulatory and contractual protections offer the investor risk mitigation and collateralization, reducing risk exposure aligned with high growth potentials.

The main driver pointing toward long term growth in the infrastructure sector is the global need for infrastructure investment. According to GIB's estimates, the gap between government infrastructure spending and infrastructure investment needs will continue to widen, highlighting the need for private infrastructure investment.

Figure 12 **Gap between Government Infrastructure Investment at Current Trends and Society's Needs**

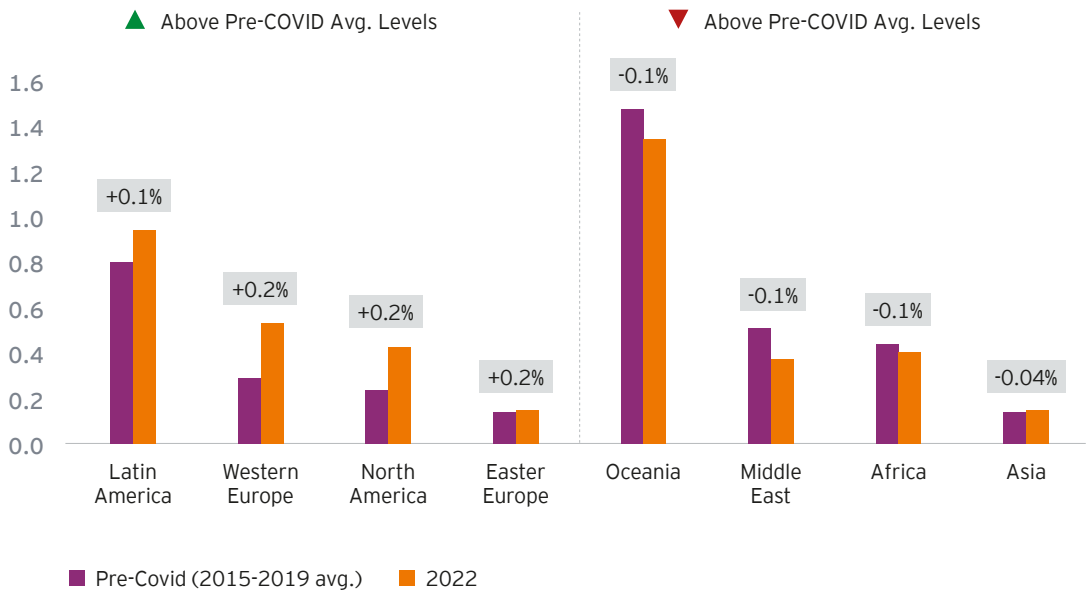


Source: Global Infrastructure Hub (GIB).

Infrastructure Investment Landscapes: Global and Sectoral Overviews

From 2018 to 2023, infrastructure investment saw significant growth, driven by increased urbanization, technological advancements, and the need for modernization of aging infrastructure. Governments and private sectors globally focused on enhancing transportation networks, energy systems, and digital infrastructure, leading to a robust market expansion.

Figure 13 **Private Infrastructure Investments in Primary Markets by Region**
(% of Regional GDP)



Source: Global Infrastructure Hub (GIB), Realfin.

$11 trillion

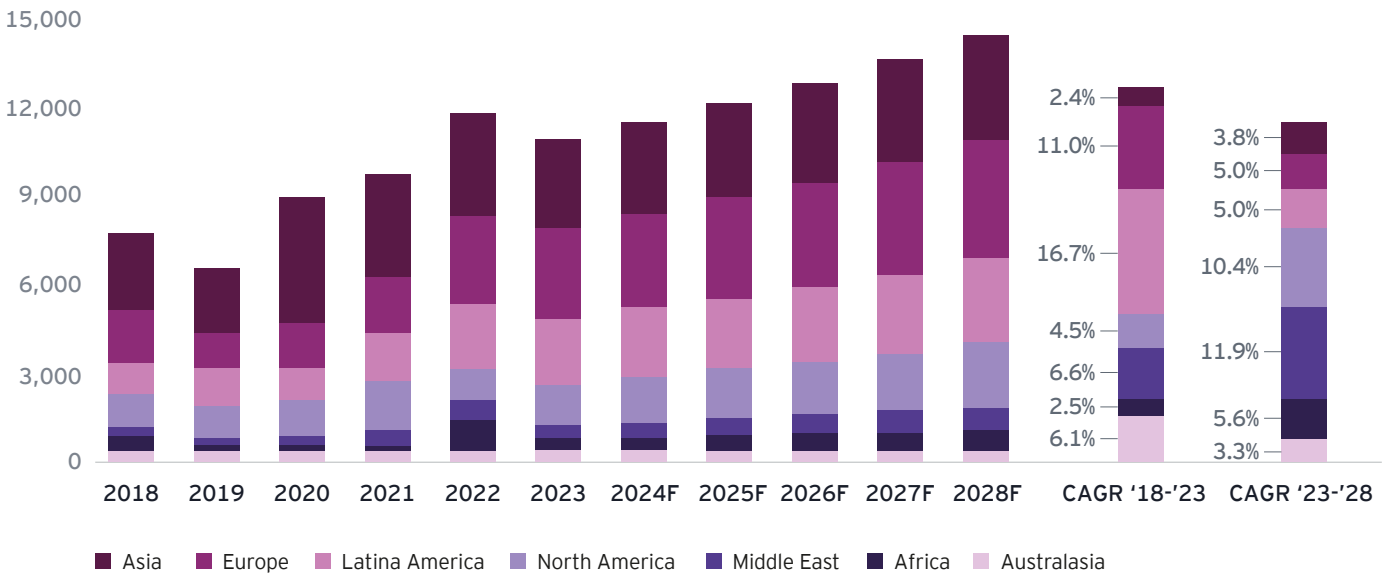
In 2022, private investment in infrastructure projects in primary markets had increased by 46% over the average for 2017-2021. Prior to the Covid era, Asia was attracting the highest share of global investment, but was surpassed by Western Europe and North America, which have had the strongest performances in the post pandemic periods in terms of private infrastructure investments as a share of the region's GDP growth. Additionally, these two regions were the preferred regions for investors in 2022.

In North America, the main driver for growth was the transport sector. There was significant policy support for infrastructure, namely the Infrastructure Investment and Jobs Act (2021), which was then and will continue to be important drivers for investment opportunities in the United States. In the case of Western Europe growth, the primary factor was the increase of fiber optic broadband networks. Looking into the near future, digital infrastructure will likely continue to boost growth for this region's infrastructure investments.

In 2023, despite the turndown experienced, the infrastructure investment market remained resilient, valued at approximately $11 trillion. This sector is poised for a compound annual growth rate (CAGR) of around 5.7% from 2023 to 2028, fueled by ongoing and new infrastructure projects, increased focus on sustainable development, and technological integration.

In 2023, despite the turndown experienced, the infrastructure investment market remained resilient, valued at approximately $11 trillion.

Figure 14 **Infrastructure Investment by Region** ($ bn)



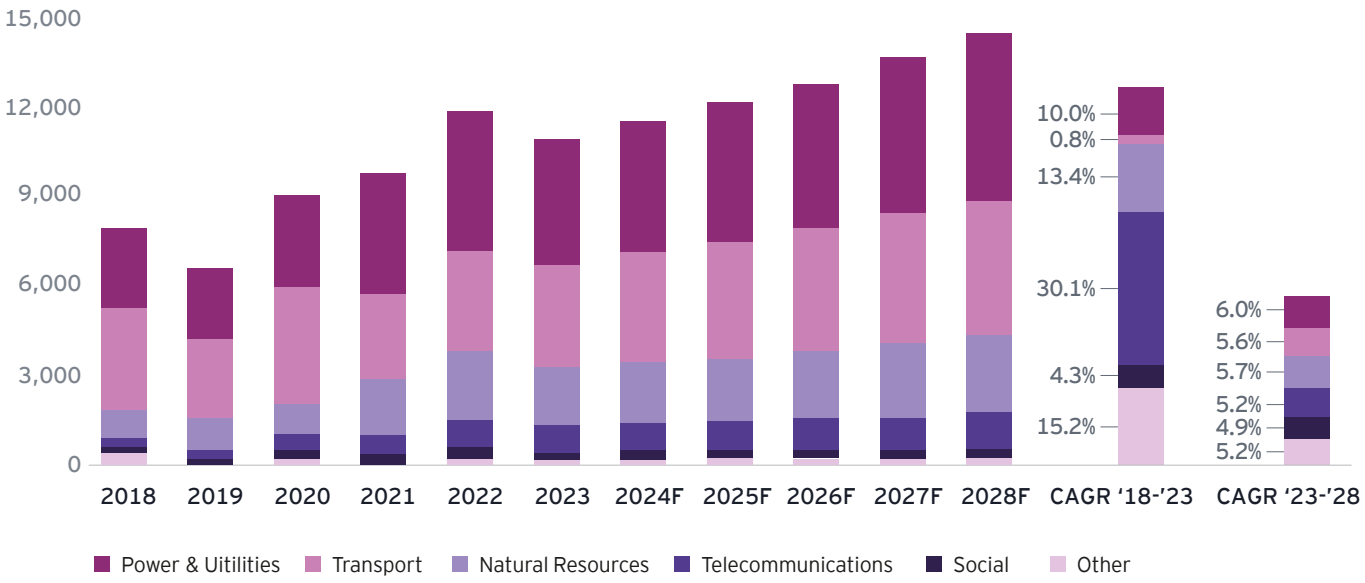
Source: Pointe Advisory Analysis.

The Middle East is projected to lead with a CAGR of 11.9%, fueled by economic diversification, urbanization, mega projects, and strategic government initiatives. North America is expected to grow at 10.4%, driven by the need to renew aging infrastructure, technological integration, increased federal funding, and a focus on sustainability. In contrast, Australasia's growth is projected to be the slowest at 3.30%, due to slower urbanization, economic constraints, and a focus on maintaining existing infrastructure rather than new large-scale projects.

The Middle East is projected to lead with a CAGR of 11.9%, fueled by economic diversification, urbanization, mega projects, and strategic government initiatives.

11.9%

Figure 15 **Infrastructure Investment by Sector** ($ bn)



Source: Pointe Advisory Analysis.

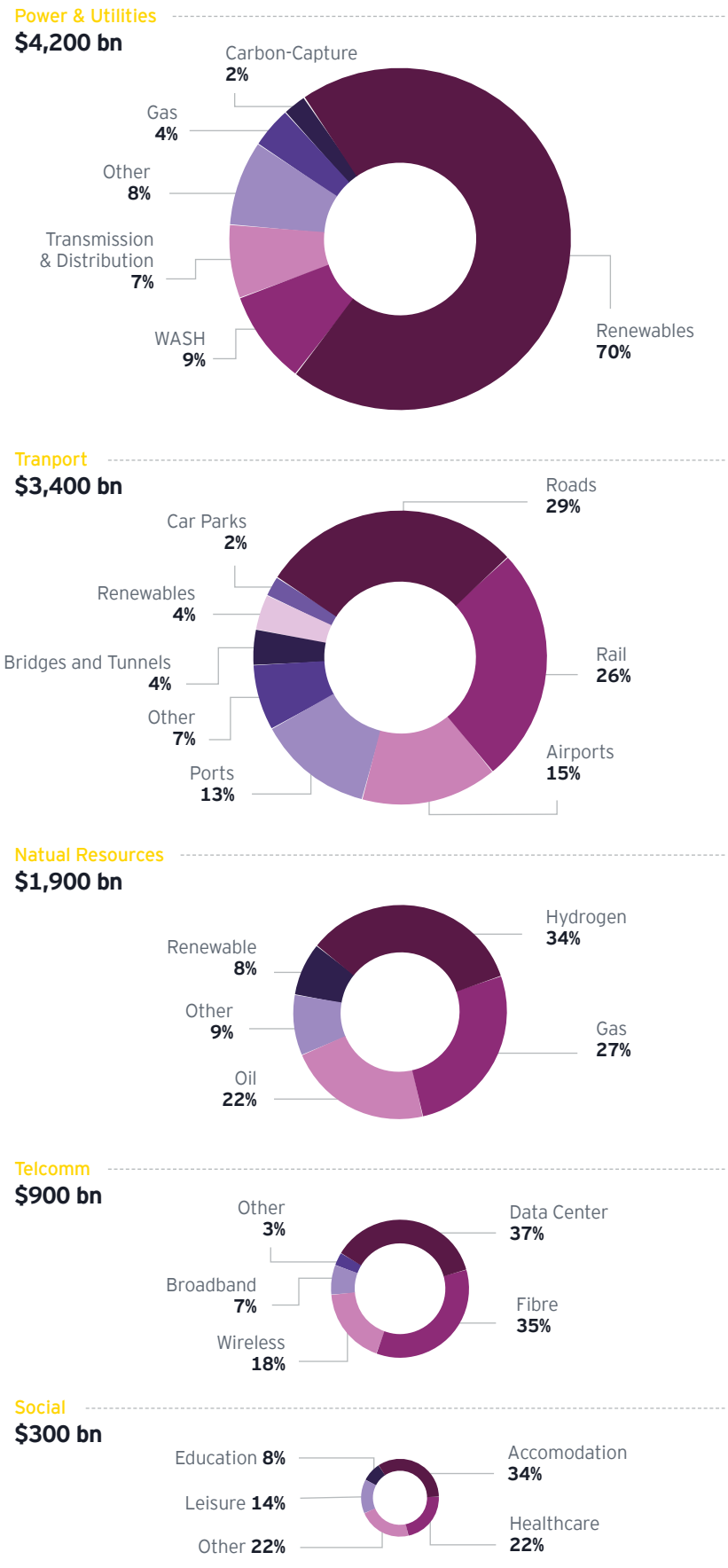
13.4%

Natural Resources saw a 13.4% growth due to the need for sustainable resource extraction and fluctuating commodity prices.

During the period from 2018 to 2023, the telecommunications sector experienced the highest growth with a CAGR of 30.1%. This surge was driven by the increasing demand for high-speed internet, the expansion of mobile networks, and the rollout of 5G technology. The COVID-19 pandemic further accelerated this growth as remote work and digital communication became essential. Natural Resources saw a 13.4% growth due to the need for sustainable resource extraction and fluctuating commodity prices. The Power & Utilities sector, growing at 10.0%, benefited from the global push toward renewable energy and decarbonization initiatives. Meanwhile, the social sector saw moderate growth of 4.3%, driven by increasing population needs and government investments in healthcare, education, and public facilities. The transport sector lagged behind, with a minimal growth of 0.8%, largely due to adequate existing infrastructure in many regions and budget constraints that limited new large-scale projects.

Looking ahead to the period from 2023 to 2028, growth rates are expected to stabilize. The Power & Utilities sector is projected to grow at a 6.0% CAGR, sustained by ongoing energy transition efforts and advancements in energy storage and smart grid technologies. Transport is expected to improve significantly to a 5.6% CAGR as urbanization and the need for sustainable transport solutions drive investments. The Natural Resources sector is projected to grow at 5.7%, driven by sustainable resource management and efficiency improvements. Telecommunications, although slowing down to a 5.2% CAGR, will continue to benefit from the expansion of 5G networks and the development of future technologies like 6G. The Social sector is expected to grow at 4.9%, reflecting ongoing investments in healthcare, education, and public infrastructure.

Figure 16 **Infrastructure Investment by Region**
($ bn)



Source: PPointe Advisory Analysis.

A breakdown of infrastructure investment into sub-sectors reveals several key drivers that are shaping the landscape and directing capital flows.

Power & Utilities (P&U)

The shift towards renewable energy sources is a significant driver in the Power & Utilities sector. Investments are increasingly being directed towards wind, solar, and other renewable energy projects as part of the global effort to transition to a low-carbon economy and meet sustainability goals.

In 2023, power made up 39.4% of private infrastructure, with renewables accounting for 33%. Renewables remain the driving force behind unlisted infrastructure deals as global renewable capacity climbed 50% from 2022 capacity level.

In 2023, energy investments represented 25.3% of the total private-sector infrastructure sector, marking an increase from 15% in 2022. Gas investments remained stable amid balancing immediate shortfalls and longer-term uncertainty, whereas low-emission fuels and CCUS opportunities appeared to be on the rise. LNG market experienced a surge in investment, with countries looking to secure LNG imports, leading to new regasification capacity being built, especially in Europe, prompted by the Russia-Ukraine war.

Transport

In the Transport sector, the primary drivers are investments in road and rail infrastructure. As urbanization continues and the need for efficient, sustainable transport systems grows, significant funds are being allocated to improve and expand road networks and rail systems. These projects aim to reduce congestion, enhance connectivity, and promote economic development.

Transport accounted for 16.2% of total private infrastructure investment in 2023, a 3% decline from 2022. Transportation infrastructure remains a key beneficiary of decarbonization policy, reflected in the 68% growth of EV infrastructure deal values in 2022.

Natural Resources

Within the Natural Resources sector, hydrogen is emerging as a crucial driver. Investments in hydrogen production and infrastructure are gaining momentum due to its potential as a clean energy source that can support decarbonization efforts across various industries, including transportation and manufacturing.

Telecommunications, Media, and Technology (TMT)

The Technology, Media and Telecommunications sector is heavily driven by the demand for data centers. Namely, digital infrastructure comprised 17.2% of overall private-sector infrastructure investment in 2023, up from 15% in 2022.

As digital transformation accelerates and the need for data storage and processing grows, substantial investments are being funneled into building and upgrading data centers to support the expanding digital economy.

Social Infrastructure

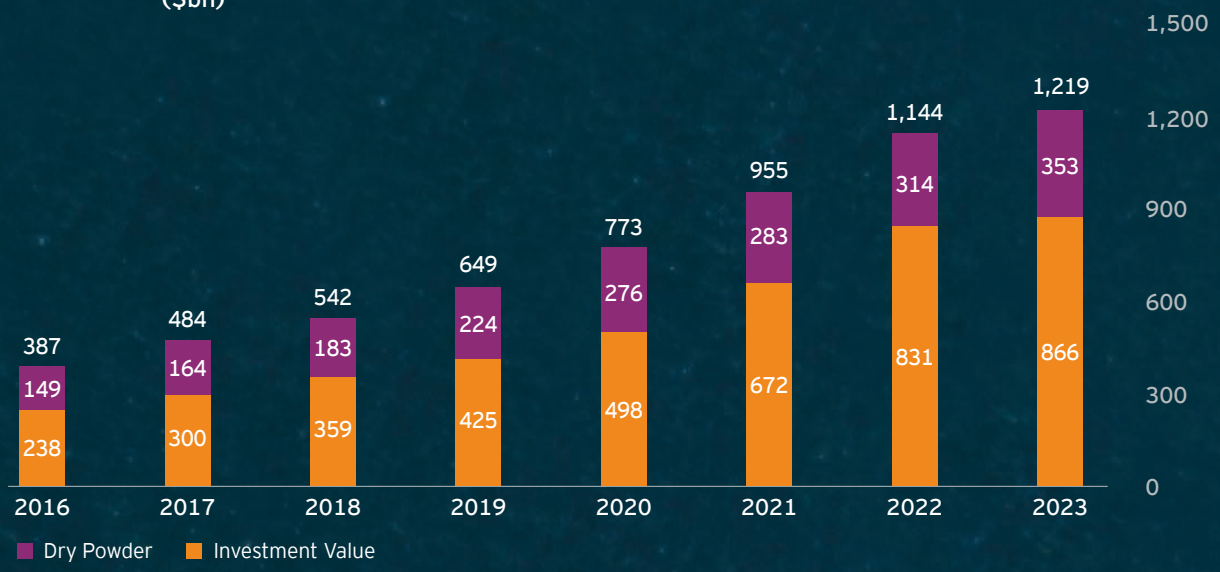
Within the Social Infrastructure sector, accommodation and healthcare are notable sub-sectors driving growth. Accommodation, with a significant 34% investment growth, reflects the need for student housing, affordable housing, and other residential projects. Healthcare infrastructure, showing a 22% growth, is driven by rising demand for healthcare services and facilities, influenced by aging populations and increased healthcare spending.

The social infrastructure sector appears to have strengthened its resilience through investments aimed at upgrading healthcare facilities, constructing climate-resilient schools, and enhancing community centers. Social infrastructure accounted for close to 1% of total private infrastructure investment in 2023. Student housing developments have attracted investor attention lately, with notable deals including DIF's investments in accommodations at LSE and Goldsmiths, University of London.

Capital Allocation Challenges in Infrastructure: Dry Powder and Investment Dynamics

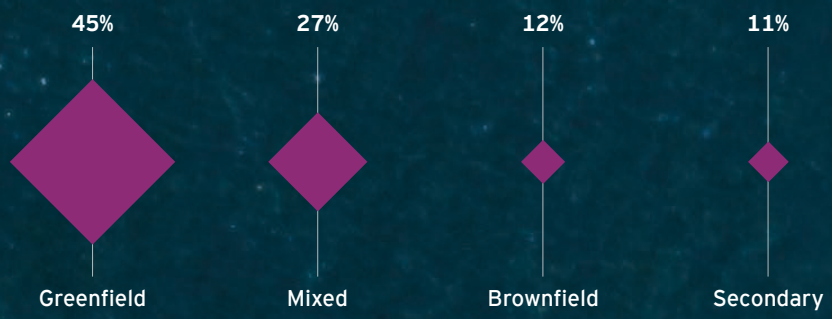
The current landscape in infrastructure investment reveals a notable accumulation of dry powder, particularly concentrated in North America and Europe, due to the limited availability of bankable projects and high hurdle rates. This surplus of capital has created a dynamic where buyers are eager to secure favorable deals, while sellers exhibit hesitancy in parting with assets at significant discounts. Consequently, bid-ask spreads have widened as negotiation impasses persist.

Figure 17 **Cumulative Private Infrastructure Capital by Component ($bn)**



Source: Preqin. Data as of October, 2023.

Figure 18 **Dry Powder by Type of Investment (% of cumulative private infrastructure)**



Source: Preqin. Data as of July, 2023.

While dry powder offers financial flexibility, its accumulation also exerts pressure to allocate funds efficiently, especially considering prolonged periods of inactivity post-raise. This situation may potentially lead to investments at elevated prices in 2024, adding complexity to deployment strategies.

In 2023, funds specializing in secondary and brownfield projects had the smallest proportion of unallocated capital, at 11% and 12%, respectively. Conversely, funds focusing on greenfield projects held the largest proportion of unallocated capital, reaching 45%. Due to the substantial upfront investment required for developing infrastructure from the ground up and the reduced capital raised in the market, greenfield projects hold the largest portion of unallocated capital. Funds focusing on these greenfield projects are particularly impacted.

In the first quarter of 2024, the consensus is that peak rates have been achieved, and that central banks will start an ease of their monetary policies, thus relieving the pressure on valuations that has created a disparity between bid and ask prices, driving dry powder levels last year.

Conclusions

The infrastructure sector has consistently demonstrated resilience and growth, even amid global disruptions and economic uncertainties. The sector's ability to maintain stability has solidified its position as a sought-after asset class for investors seeking yield protection against market volatility.

The fundraising landscape for infrastructure experienced a downturn in 2023 due to economic headwinds. High inflation rates and rising interest rates drove ERP levels down, creating a slow fundraising environment in the sector. Furthermore, a valuation gap was created in the market, leading to capital allocation problems, which drove dry powder to higher levels than previous years.

Coming into 2024, the macroeconomic environment appears increasingly favorable for infrastructure investments. Even if inflation levels are not yet at central banks' targets, the 2022 peak levels have been left behind. Market consensus is that interest rates are bound to decline, pointing toward the closing of valuation gaps, which will propel investments and, in turn, fundraising. The positive capital raising in the first quarter of 2024 indicates a shift in investor sentiment, suggesting a potential uptick in fundraising as concerns over interest rates and asset values begin to subside.

The accumulation of dry powder, especially in North America and Europe, presents both opportunities and challenges for capital allocation. The efficient deployment of these funds will be critical in 2024, as the market adjusts to peak interest rates and central banks potentially ease monetary policies. Moreover, the enduring need for continued investment in infrastructure presents an ongoing opportunity for investors to realize the targeted benefits of private infrastructure, even in the event of normalization within the broader macro and market environment in 2024.

Debt financing within the infrastructure sector has shown remarkable growth, with infrastructure debt fundraising outperforming other strategies in 2023. As we move into 2024, infrastructure debt is expected to continue offering attractive risk-adjusted returns, playing a crucial role in the sector's fundraising landscape. On the other hand, while the equity strategies in infrastructure were perhaps not as appealing in the past year, the anticipated reactivation in the markets will likely drive returns upward as yields are adjusted downward upon further inflation control.

As a result of the long-term, high-yield environment, funds have favored investment strategies that satisfied their heightened return requirements. Core plus and value add strategies have surged in the past year and will likely continue to do so in the near future as the risk-return profiles are a best match for investor preferences in the current landscape. Nonetheless, core strategies continue to provide investors with downside protection and high cash yields and are expected to recuperate their share of fundraising.

In terms of geographical trends, North America and Europe have emerged as preferred destinations for infrastructure investments in the post pandemic era, with particular growth within the transport and digital infrastructure sectors. The report anticipates continued growth in these regions, driven by policy support and technological advancements. Additionally, the Middle East is positioned to lead global investment, fueled by mega projects and government initiatives.

Power and utilities continue to be the strongest sector within infrastructure investments, boosted by the global shift towards renewable energy sources. In the near term, digital infrastructure will likely be the driving force for infrastructure investments, especially in Europe, where fiber connections, telecom towers and data centers are in high demand.

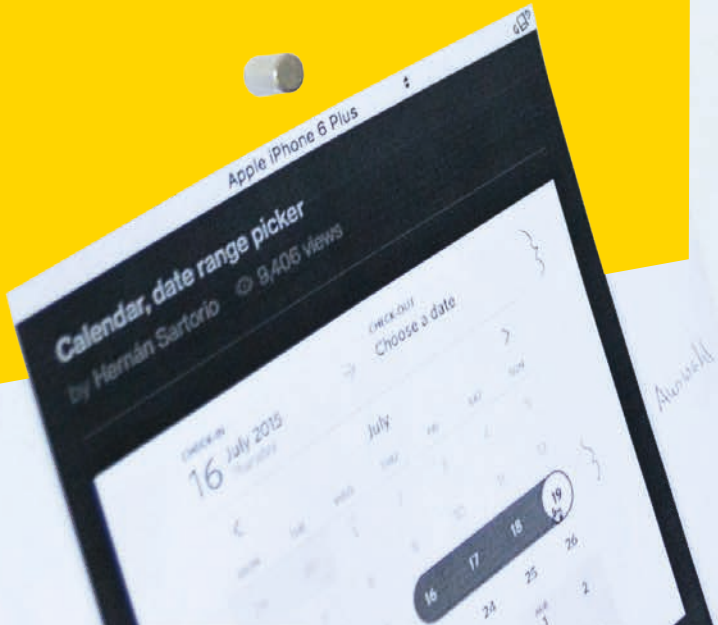
The infrastructure investment sector is poised for a resurgence in fundraising and deployment activities in 2024. The sector's inherent resilience, coupled with favorable macroeconomic indicators and strategic fund management, positions it for continued growth and success in the coming years. Investors can look forward to capitalizing on the opportunities that arise from a stabilizing economic environment and the ongoing need for infrastructure development globally.

1.2. EY Infrastructure Barometer 2024

The EY Infrastructure Barometer initiative includes an annual survey of senior executives from large corporates, infrastructure investors, financial institutions, and private equity houses around the world, conducted by the EY Strategy and Transactions team in Spain to assess the status and investment confidence in the infrastructure sector in Spain.

The respondent community comprises an independent panel of senior executives and selected EY clients and contacts, including leaders of the infrastructure ecosystem's most relevant stakeholders. In this edition we have had the collaboration of 80 experts and professionals who have given us their vision of the current situation of the infrastructure sector, as well as their expectations for the coming years.

Regarding the composition of the statistical sample, it should be noted that 84% of the answers received came from investment funds and corporates, of which 51% manage asset portfolios of more than €1 billion and have a footprint across the World (48%), Europe/EMEIA (35%) or Spain (17%). Of those respondents, 33% are investing under Art. 9 funds and 37% under Art.8. The remaining respondents are not attached to any ESG regulation.



Main Conclusions

The Spanish infrastructure sector is highly significant within the EU for institutional and corporate infrastructure investors, primarily due to the high quality of existing infrastructure. Survey respondents highlight the appeal of renewable energy assets and the energy transition, along with Spain's pivotal role in the Eurozone economy, as key factors influencing their investment decisions.

Nevertheless, the infrastructure sector in Spain still faces certain weaknesses and risks that affect the performance of current investments, such as political and regulatory uncertainty. Investors are particularly concerned about the limited number of greenfield opportunities in the market.

The balance between risk and return in the current infrastructure investment landscape is seen as neutral or somewhat unbalanced. Asset valuation and increased competition for acquisitions have emerged as major challenges for returns in the coming year. Following the slowdown in interest rate hikes, investor expectations suggest a potentially slight or moderate decrease over the next 24 months. In this scenario, most investors view organic growth and operational turnaround as key opportunities to enhance the performance of their existing investments, rather than relying on inorganic growth or refinancing strategies.

Renewables and energy transition assets have notably demonstrated resilience as the preferred investment sector over the past 12 months, with transportation and mobility sectors following closely. This trend aligns with the significant transformations occurring in these industries. Survey respondents indicated a strong preference for channeling investments into these two sectors in the upcoming year.

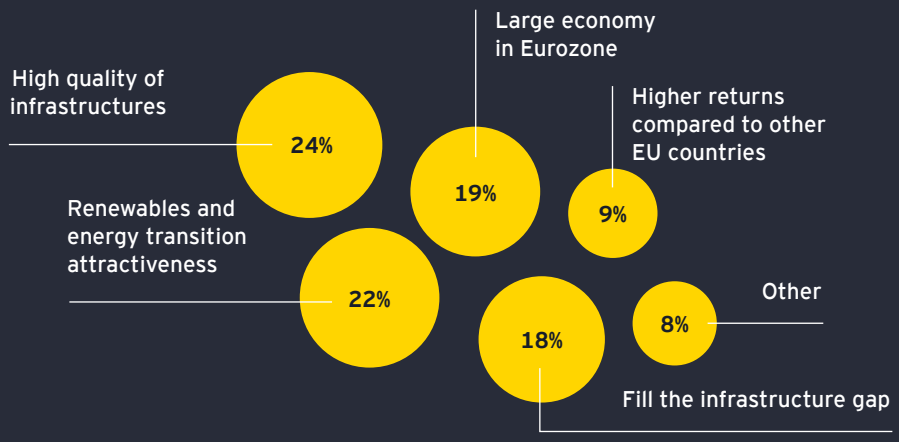
Technology is increasingly becoming an area of interest and a potential core segment in the next years, in particular for energy, transportation and TMT sectors. However, only 29% of surveyed respondents say that technology is currently part of their investment strategy. This suggests significant potential for development, particularly through the integration of AI and analytics.

In response to market dynamics and significant investor interest, we have conducted targeted sector analyses on data centers and the biogas/biomethane industries in Spain for the Infrastructure Barometer 2024 edition. We recognize the substantial potential and investment appeal of these two industries as critical drivers for advancing digitalization and decarbonization efforts within the broader industry. Our observations reveal that nearly half of the investors surveyed have either contemplated investments in biogas/biomethane or data centers over the past year or are considering such investments in the forthcoming year.

Key Insights from the Survey

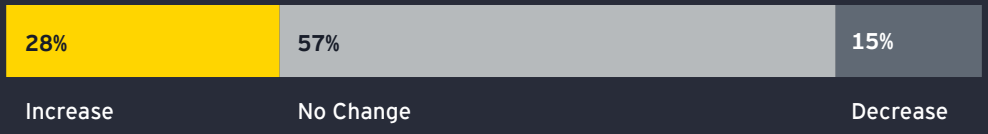
1. **Spanish Infrastructure Sector:** In the last four years, 80% of consulted investors have been active in the Spanish infrastructure sector, citing high-quality infrastructure and the attractiveness of the renewable energy and energy transition sectors as the main factors driving investments. Other reasons provided by respondents include geographical diversification, market knowledge and having reliable and solid local sponsors. Most investors (74%) do not plan to divest their Spanish infrastructure holdings, though competition for investments is expected to increase: 62% of experts expect to see increasing competition for infrastructure investments or financing in Spain in the next 12 months.

Figure 18 **Key reasons for investors to invest in the Spanish infrastructure sector**



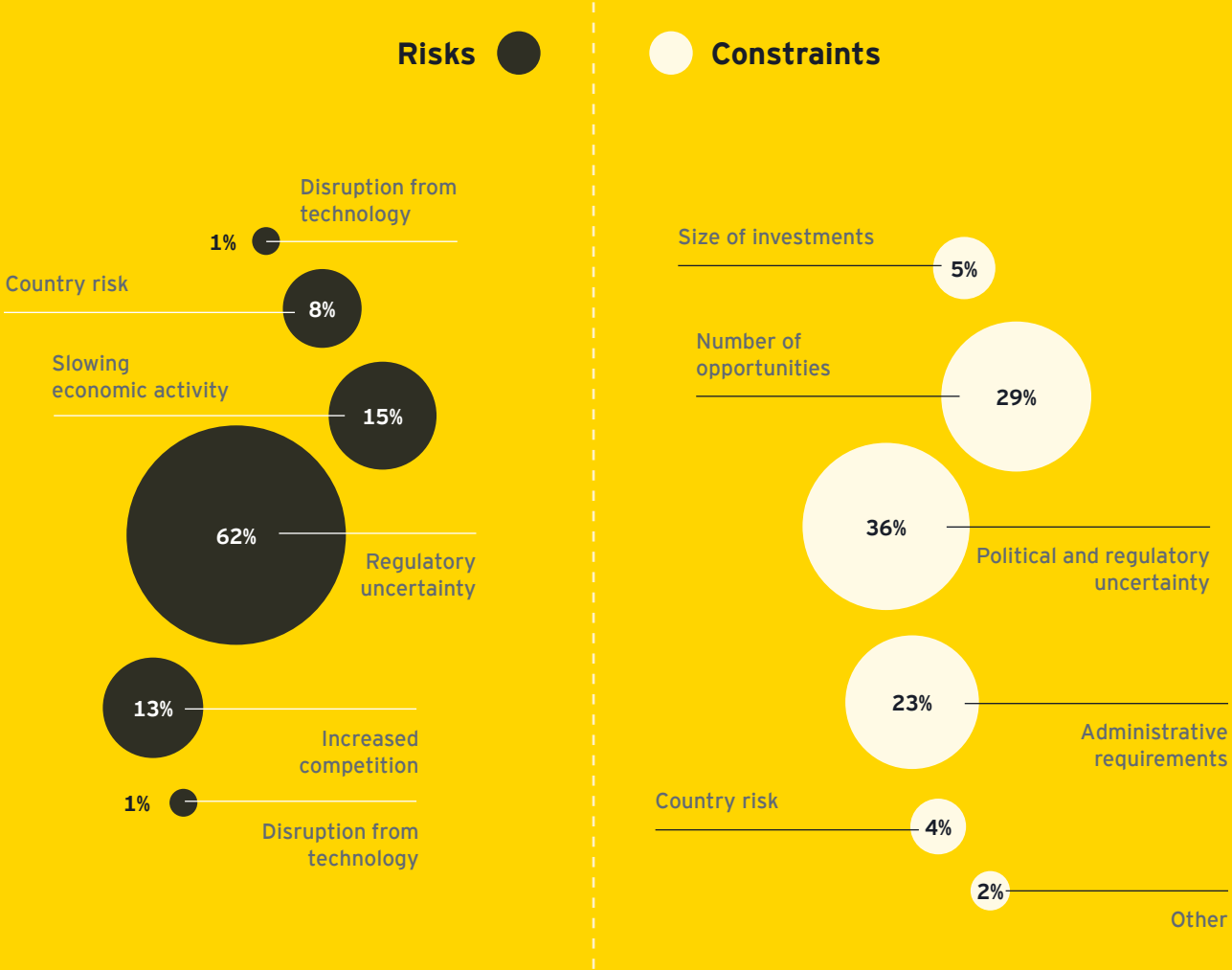
However, more than a quarter of consulted experts expect to increase the number of deals in Spain compared with the past 12 months.

Figure 19 **Expectation of number of deals completed over the next 12 months**



2. **Risks and Constraints:** Regulatory uncertainty is cited as the most significant external risk, impacting the performance outlook in the Spanish infrastructure sector (62%), followed by slowing economic activity (15%). Uncertainty is also the most cited constraint in investing or financing greenfield infrastructure initiatives in Spain (36%) followed by the number of opportunities (29%) and administrative requirements (23%).

Figure 20 **Main constraints and risks in investing or financing the Spanish infrastructure sector**



3. **Interest Rates and Risk/Return Balance:** A moderate decrease in interest rates is predicted by 46% of investors over the next 24 months, while 43% expect little change. The risk/return balance is rated at an average of 2.71 out of 5, showing moderate skepticism.

Figure 21 **Risk/return balance perception in the current infrastructure landscape**

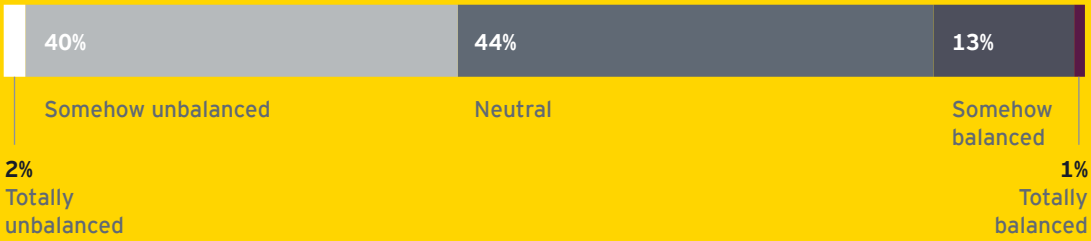
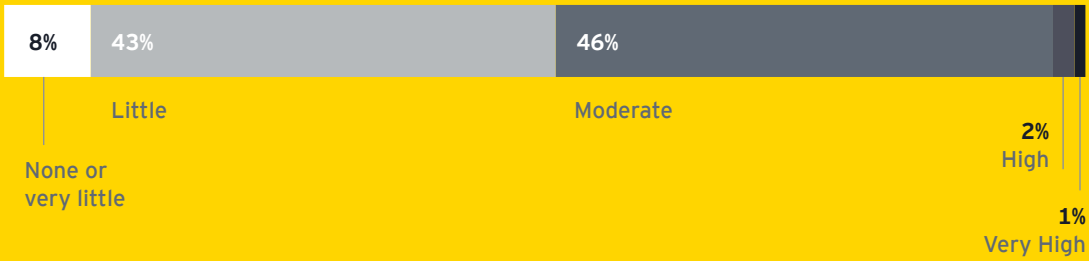
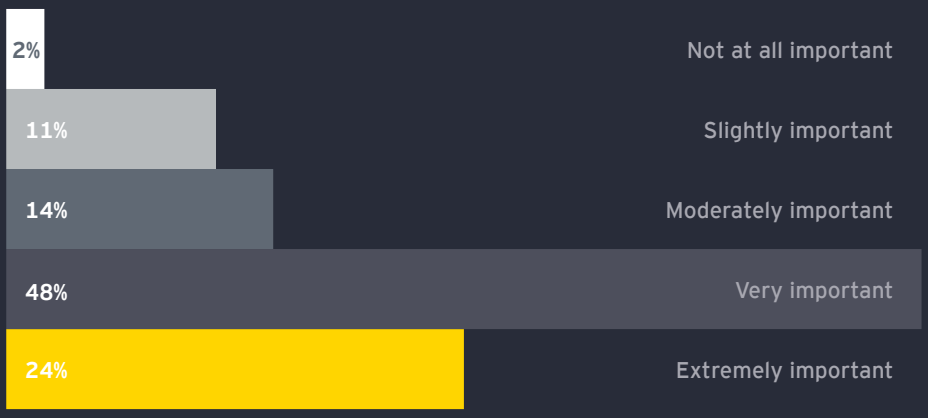


Figure 22 **Expectation of interest rates decrease in the next 24 months**



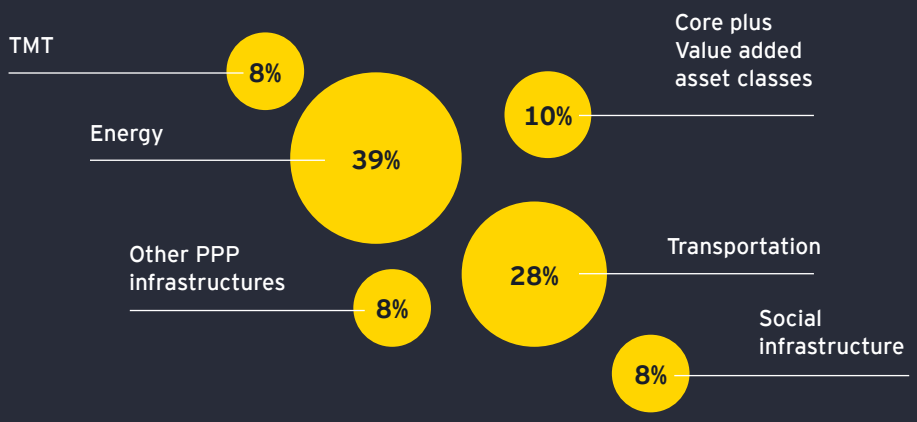
4. **ESG Criteria:** A significant 72% of investors consider Environmental, Social, and Governance (ESG) criteria as 'very' to 'extremely' important, with an average importance rating of 3.81 out of 5 in their investment strategy.

Figure 23 **Importance of ESG criteria in investment strategy**



5. **Sector Focus:** When asked about their investment in infrastructure during the past year, the most notable sectors were transportation and mobility (23%) and renewables (21%). The energy sector, particularly renewables, is a key focus sector for 39% of investors for the following 12 months, while 44% of consulted experts point to energy transition as the most attractive core plus asset category in Spain.

Figure 24 **Expected investment in the Spanish infrastructure sector during the following year by sector**



6. **Portfolio Optimization:** Infrastructure investors prioritize internal development as the primary way to improve investment performance, with 35% identifying organic growth as the greatest opportunity. This indicates a preference for strengthening and expanding existing operations from within. Operational turnaround is also a significant focus, with nearly a quarter of investors seeing it as a key strategy, implying that there is a notable interest in improving efficiency and profitability through internal changes.

7. **Technology Investments:** Technology investments are part of the strategy of just 29% of consulted investors, with artificial intelligence (33%) and data analytics (18%) seen as having the greatest potential benefit to the infrastructure sector. The subsectors that are believed to benefit most from technology investment are Energy (29%), Transportation (27%) and TMT (21%).

Figure 25 **Investors' preferences for portfolio performance improvement**

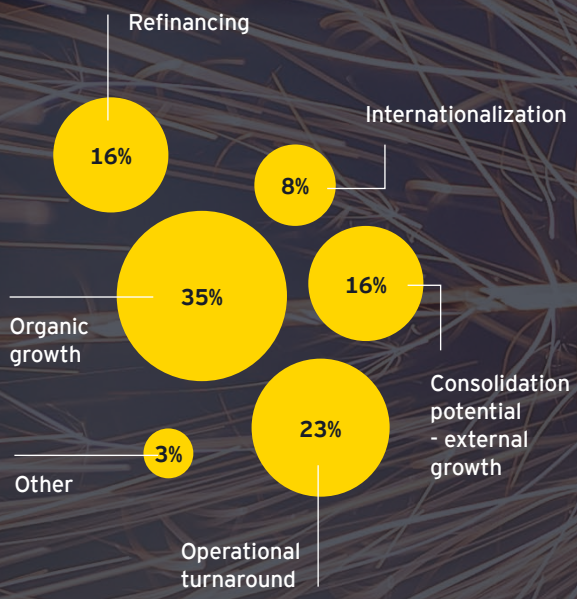
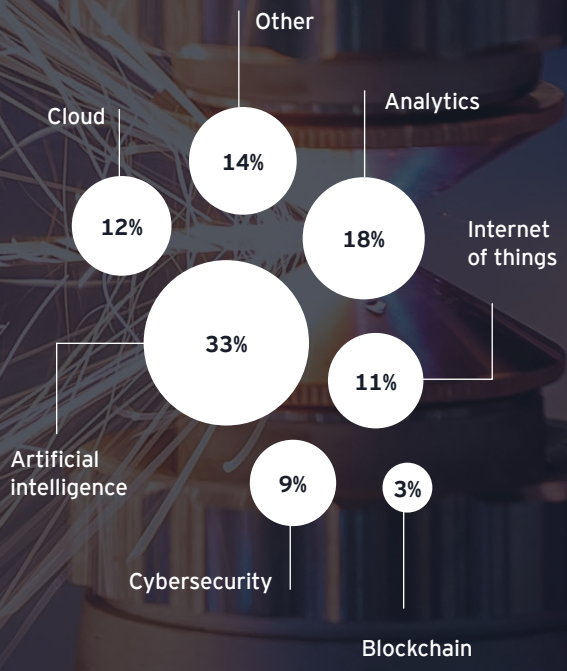


Figure 26 **Technological applications expected to bring the greatest benefits to the infrastructure sector**



8. **Data Center Infrastructure Focus:** The expected interest in data center infrastructure seems moderate for the next 12 months. More than one in five (22%) of investors are planning to invest actively, with an average interest of 2.77 over 5 and 22% planning on investing actively. Among investors with Spanish scope, 50% have never considered investing in data centers, while 20% plan to invest actively.

9. **Biogas Infrastructure Focus:** The outlook for interest in biogas infrastructure investment for the next 12 months looks similar. Investors express an average interest in biogas infrastructure of 2.64 over 5, with 19% considering actively investing during the next 12 months. Within the Spanish scope, one in three investors have never considered this option, while 40% plan to invest often or actively.

Figure 27 **Investment outlook for data centers over the next 12 months**

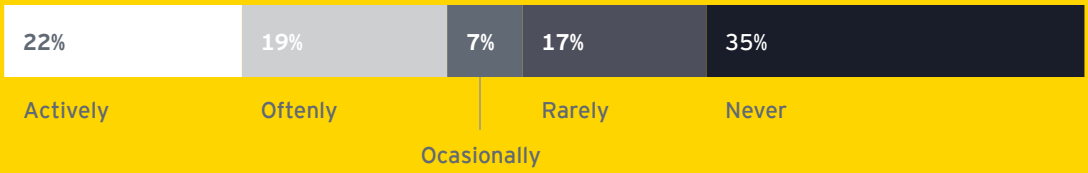
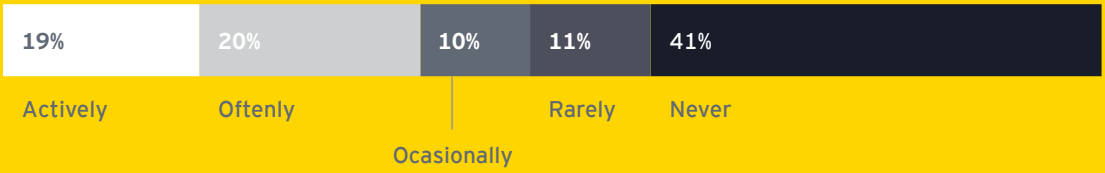


Figure 28 **Investment outlook for biogas over the next 12 months**



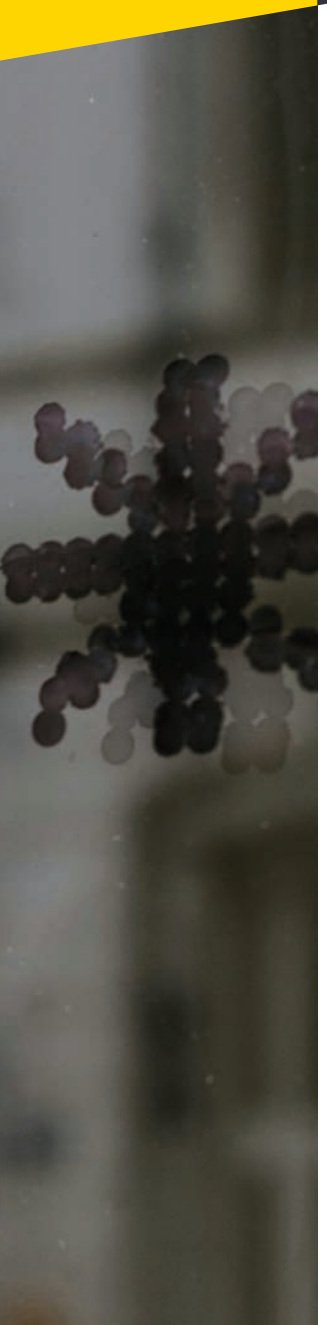
Technical Survey Datasheet

- **Methodology:** Quantitative survey with supplementary qualitative questions.
- **Sample Size:** 80 respondents, comprising senior executives from infrastructure funds, institutional investors, and financial institutions.
- **Survey Technique:** Online questionnaire distributed via email and professional networking platforms. Data collected and analyzed by EY Insights Spain.
- **Data Collection Period:** June 15, 2024 to June 30, 2024.

2

Data Centers Unveiled: Navigating the Spanish Landscape

Main trends, Spanish market capacity and investment opportunities



2.1. Introduction

In the realm of business, data is the modern equivalent of oil, shaping our daily lives and driving transformative changes across industries. Every day, businesses and individuals witness the profound impact of data generation, storage, processing, transmission, and analysis, offering immense potential for financial growth. The exponential increase in global data traffic, driven by rising mobile usage and the pervasive influence of digitalization, cloud computing, over-the-top video, the Internet of Things, and artificial intelligence, underscores the vast opportunities within the data landscape.

At the heart of this digital revolution are data centers, the nerve centers housing high-speed computing infrastructure that power innovations such as widespread 5G adoption and artificial intelligence applications. Recent trends indicate a significant shift toward cloud-based data storage and computing solutions, underscoring the growing importance of data centers as critical components of modern infrastructure.

In Europe, the leading data center markets are often denoted by the acronym FLAP-D, representing Frankfurt, London, Amsterdam, Paris, and Dublin. Despite their pivotal roles, these markets encounter inherent limitations, such as spatial constraints hindering expansion efforts amid soaring demand, and other markets are emerging like Madrid and Milan. Nevertheless, investments in data center ventures continue to be highly appealing, buoyed by unwavering demand drivers for data center capacity.

This white paper outlines:

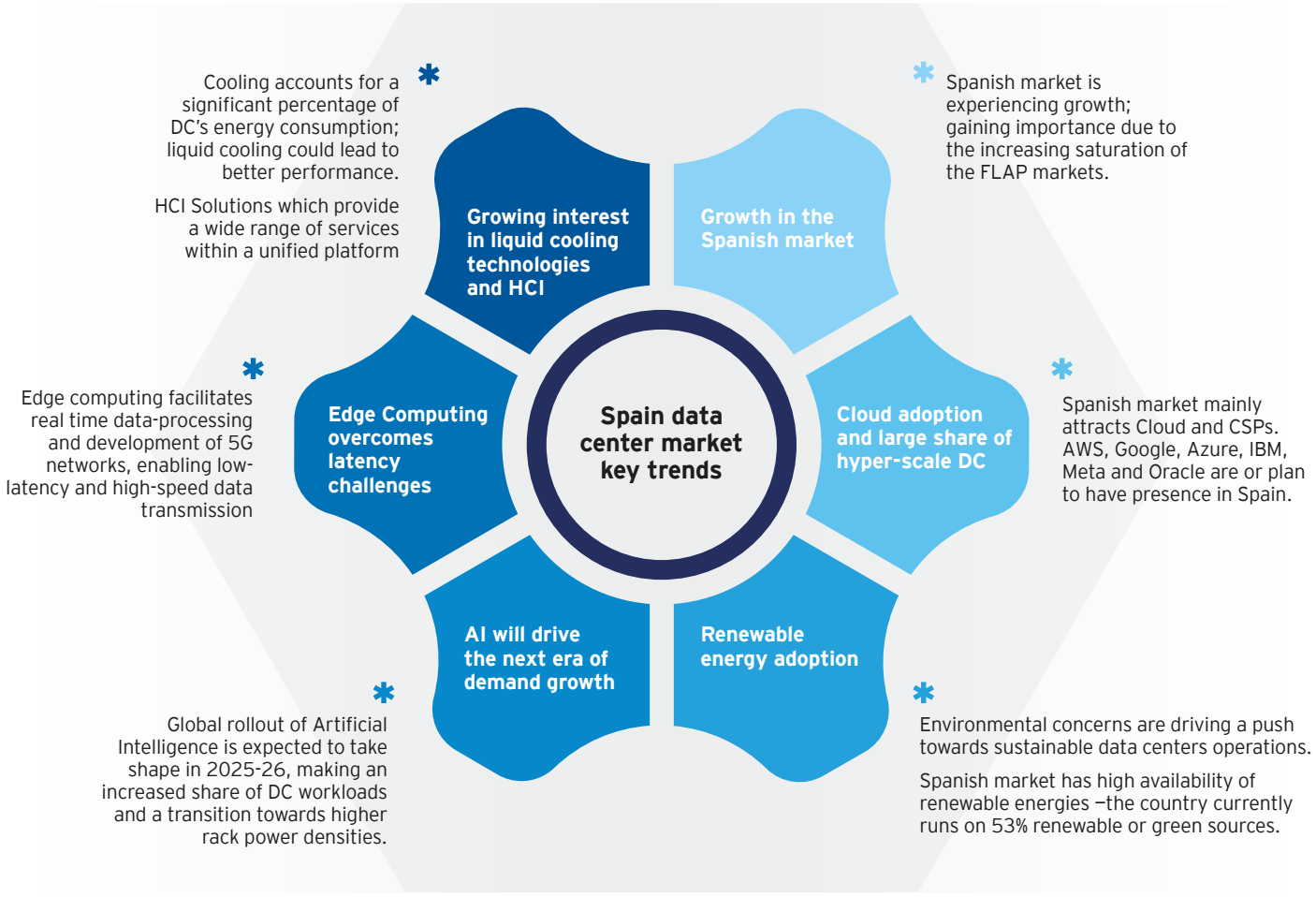
- The main trends shaping the Spanish market for data centers and their significance.
- The landscape of the data center market in Spain, highlighting forecast market capacity, key investments in the country and the growing interest among major corporations and hyperscalers.
- Investment opportunities within the data center sector, including financial performance outcomes and notable transaction values observed in recent years.

2.2. What are the main trends within the Spanish data center market?

The data center sector is undergoing rapid change, driven by technological progress and shifts in the market landscape. As the digital infrastructure transforms and sustainability becomes a priority, alongside the rise of artificial intelligence, several trends are shaping the market.

The data center industry in Spain is witnessing significant growth due to increased reliance on cloud computing and digital infrastructure. Major investments are flowing into cities like Madrid, driven by rising demand expected to surge further. Spain's commitment to renewable energy and the Digital Spain 2025 agenda are additional drivers of industry growth.

Additionally, the rise in demand for managed cloud services is fueling investment in hyperscale data centers, which are emerging strongly throughout Spain. Initiatives in green hydrogen and Spain's strategic position as a submarine cable hub are further propelling industry expansion, driven by the proliferation of digital and cloud-based storage practices.

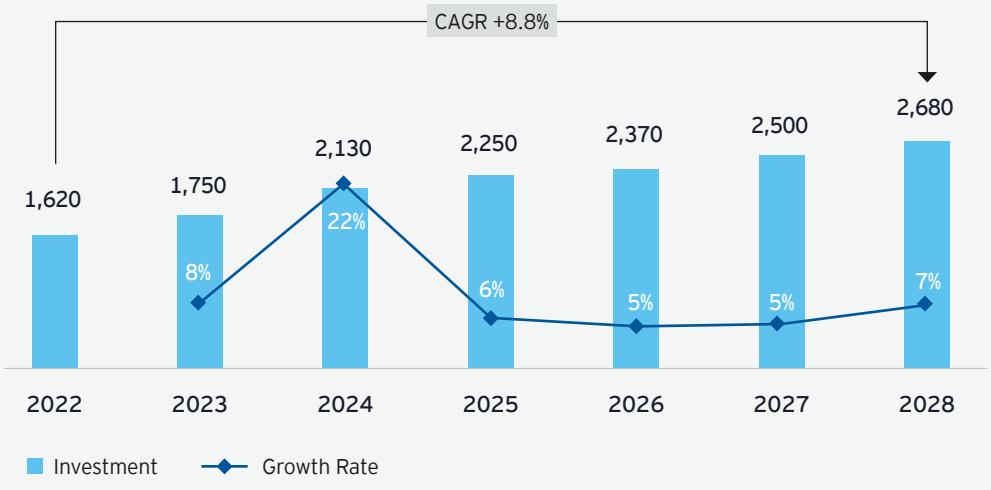


Key trends observed in the market include: i) Growth in the Spanish market; ii) Cloud adoption and large share of hyperscale data center: iii) Renewable energy adoption; iv) Artificial Intelligence (AI); v) Emergence of Edge Computing; vi) increasing interest in liquid cooling technologies and the movement towards hyperconverged infrastructure.

Growth in the Spanish Market

The global data center market is poised for substantial growth until 2031, fueled by advancement in AI, cloud computing, and evolving market demands. Spain emerges as a prominent player, expected to reach more than $600 million in colocation data center industry revenues by 2027. Positioned beyond the traditional FLAP (Frankfurt, London, Amsterdam, Paris) data center market, Spain ranks third in Europe for the number of new data center projects, following the UK and Germany. Madrid, Barcelona, and Bilbao are the pivotal cities seeing significant expansions, with Madrid emerging as a vital node in the global technological infrastructure network, heightening Spain's attractiveness for data center investments.

Figure 29 **Data center investment in spain** ($m)



Source: EY.

The country's robust connectivity infrastructure, bolstered by substantial investments and the deployment of three submarine cables linking Spain with the USA, Latin America and Africa, has facilitated substantial growth in data traffic volumes and speed. This attractiveness has lured global data center players, such as DE-CIX, the largest Internet Exchange Point, which has established new facilities in Madrid, further cementing Spain's position as a data center hub.

$600M

Spain emerges as a prominent player, expected to reach more than $600 million in colocation data center industry revenues by 2027.

Large Share of Hyperscale Data Centers

The allure of the Spanish market for Cloud Service Providers (CSPs) is undeniable, with major players such as AWS, Google, Microsoft, and Oracle establishing or in the process of establishing a significant presence in Spain. In response to data localization regulations in certain Western European countries, hyperscale data center operators are constructing their own facilities, driving increased investments nationwide.

Typically, these CSPs choose to either construct their own data centers or lease space in externally managed facilities. The surge in demand for managed cloud services, driven by the exponential migration of enterprise workloads to the cloud (with global cloud services expected to host ~35% of enterprise workloads by 2026), has prompted a substantial increase in investments in hyperscale data centers across Spain.

Microsoft has announced the opening of its first cloud region of data centers in Spain, located across multiple sites in the Community of Madrid. From these centers, Microsoft will provide AI and cloud services to companies and public entities in Spain and throughout Europe, ensuring reliability, security, privacy, and data residency. Additionally, Microsoft plans to develop a Cloud Region in Aragon, with an expected investment of €6.69 billion over the next ten years. Similarly, Google Cloud has announced a new cloud region in Madrid through a partnership with Telefonica, solidifying Spain's position in the global cloud landscape. In November 2022, Amazon Web Services (AWS) launched its eighth European infrastructure region in Aragon with a $2.6 billion investment over the next decade. Oracle also expanded its cloud presence by opening its 40th global cloud region in Madrid in September 2022, marking Spain's first Oracle Cloud Infrastructure (OCI) region.

Furthermore, in November 2022, the Spanish government unveiled a Public Administration Cloud Services Strategy, emphasizing the prioritization of cloud-based services by government departments. In addition, IBM opened a Cloud multi-zone region in Madrid, through the development of 3 data centers and potential of 35 MW; while Meta is building a €1 billion data center campus in the Toledo region of Spain.

74%

Spain has outlined ambitious goals to achieve 74% renewable electricity generation by 2030 focusing primarily on wind and solar energy.

Renewable Energy Adoption

The data center industry is facing increasing pressure to prioritize sustainability, environmental friendliness, and energy efficiency, as it currently accounts for 2% of global greenhouse gas emissions. This necessitates proactive measures to reduce energy consumption, integrate renewable energy sources, and enhance cooling systems.

Investing in sustainability has become a focal point within the data center industry, with 87% of corporate executives intending to increase investments in sustainability technology by 2024. To meet environmental, social, and governance (ESG) goals, the European data center industry has committed to self-regulatory agreements like the Climate Neutral Data Centre Pact, aiming for net-zero emissions by 2030. Although sustainability initiatives may entail higher upfront costs, they offer long-term benefits such as enhanced reputation and reduced community resistance. For data center companies, obtaining renewable energy credits is essential to demonstrate their commitment to sustainability.

Spain has outlined ambitious goals to achieve 74% renewable electricity generation by 2030 focusing primarily on wind and solar energy. The country also aims for a 23% reduction in greenhouse gas emissions and 42% renewables in energy use. To incentivize investments in renewable energy infrastructure, the country has introduced subsidies and tax incentives.

Consequently, Spain is witnessing heightened interest and long-term investment from hyperscale firms like Microsoft, Google, and AWS, all of whom have ambitious sustainability goals to achieve. The Spanish market boasts significant appeal due to its abundant renewable energy resources, with the country currently deriving 53% of its energy from renewable or green sources. For instance, IBM's Multizone Cloud Region in Madrid is powered by 100% renewable energy, aligning with the growing emphasis on sustainability in the data center industry.

In conclusion, sustainability and renewable energy are crucial topics and trends in the data center industry, with Spain emerging as a key player due to its ambitious renewable energy goals and favorable environment for green data center investments.

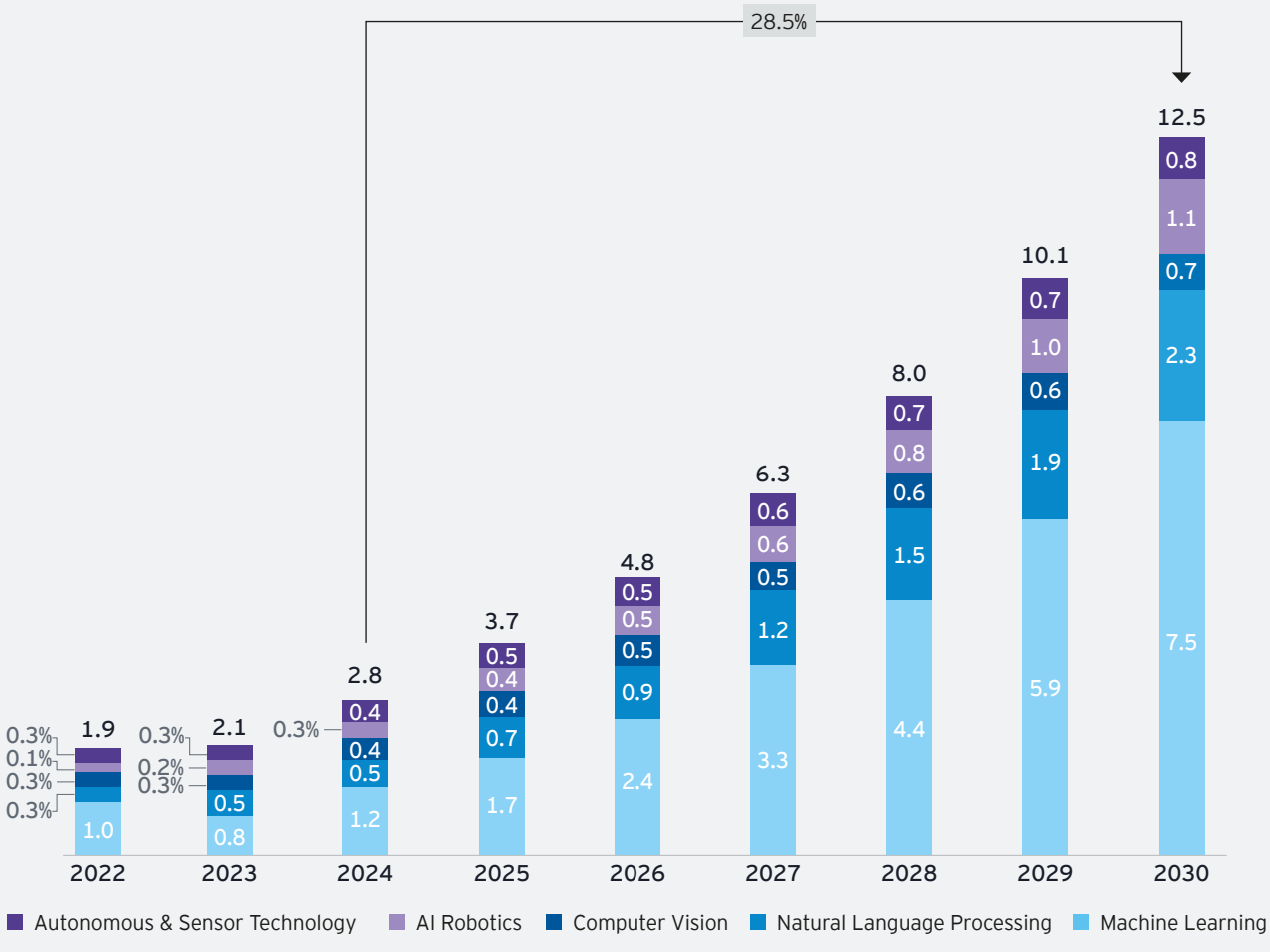
Artificial Intelligence to Drive the Next Era of Demand Growth

Artificial intelligence is a significant trend in Spain's data center market. Forecasts indicate Spain's AI market will surpass $10 billion by 2029, driven primarily by machine learning.

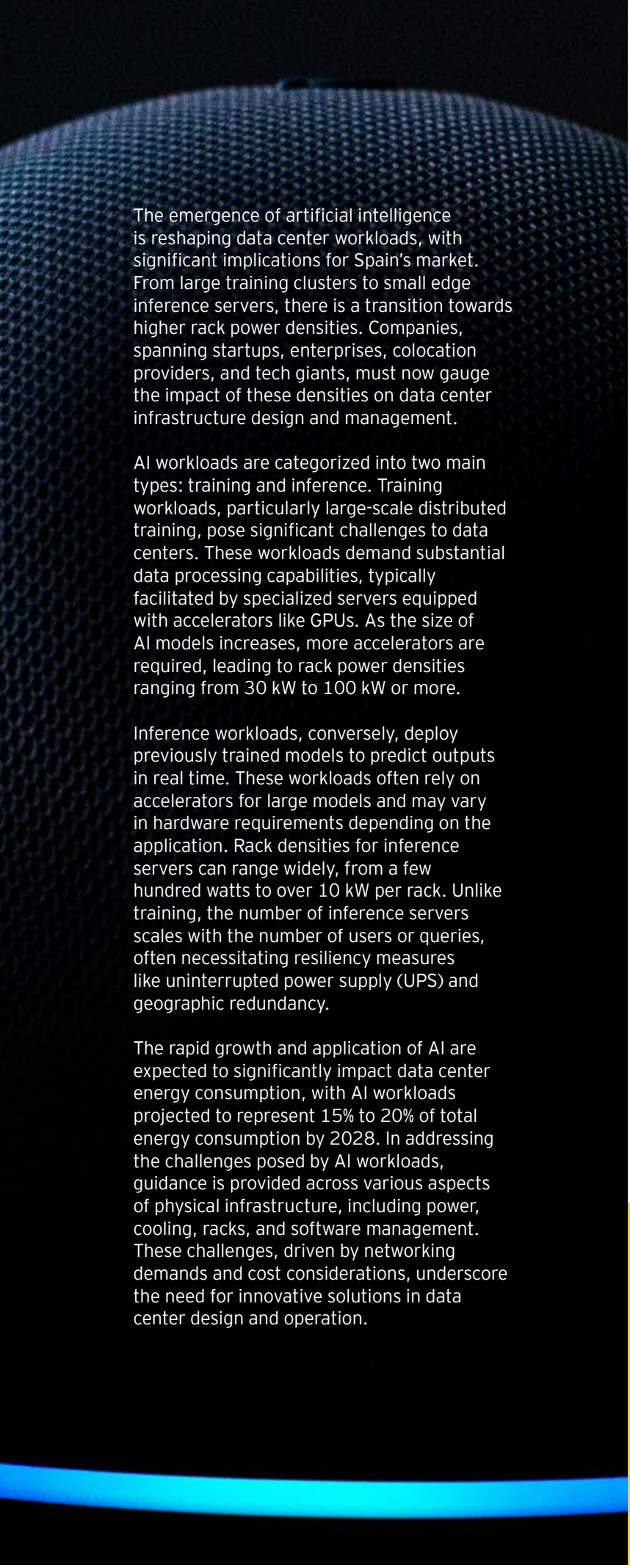
Spain has taken proactive measures to foster innovation and regulatory compliance in AI, including the establishment of a Regulatory Sandbox on AI in June 2022, allowing companies to test technical solutions and compliance procedures without undue burdens.

Legislative updates, like as the revision of the General Law on Telecommunications in June 2022, underscore Spain's commitment to digital infrastructure, including a minimum Internet download speed of 100 Mbps for Spanish users by June 2023. The private sector is also driving innovation in AI in Spain; additionally, global players like HPE are establishing centers of excellence for AI development.

Figure 31 **Artificial Intelligence market size, Spain** (billion $)



Source: EY.



The emergence of artificial intelligence is reshaping data center workloads, with significant implications for Spain's market. From large training clusters to small edge inference servers, there is a transition towards higher rack power densities. Companies, spanning startups, enterprises, colocation providers, and tech giants, must now gauge the impact of these densities on data center infrastructure design and management.

AI workloads are categorized into two main types: training and inference. Training workloads, particularly large-scale distributed training, pose significant challenges to data centers. These workloads demand substantial data processing capabilities, typically facilitated by specialized servers equipped with accelerators like GPUs. As the size of AI models increases, more accelerators are required, leading to rack power densities ranging from 30 kW to 100 kW or more.

Inference workloads, conversely, deploy previously trained models to predict outputs in real time. These workloads often rely on accelerators for large models and may vary in hardware requirements depending on the application. Rack densities for inference servers can range widely, from a few hundred watts to over 10 kW per rack. Unlike training, the number of inference servers scales with the number of users or queries, often necessitating resiliency measures like uninterrupted power supply (UPS) and geographic redundancy.

The rapid growth and application of AI are expected to significantly impact data center energy consumption, with AI workloads projected to represent 15% to 20% of total energy consumption by 2028. In addressing the challenges posed by AI workloads, guidance is provided across various aspects of physical infrastructure, including power, cooling, racks, and software management. These challenges, driven by networking demands and cost considerations, underscore the need for innovative solutions in data center design and operation.

Emergence of Edge Computing Overcomes Latency Challenges

The rollout of 5G networks, which require high-speed, low-latency data transmission, is driving the need for new edge data centers in Spain. Edge computing involves real-time data processing at or near the source of data generation. As a result, an edge data center is a decentralized facility equipped with cooling and power infrastructure, providing storage and computing capabilities in proximity to where the data is generated or utilized.

Partnerships between companies like Vapor IO and AWS, announced in February 2023, further underscore the integration of edge computing solutions with 5G infrastructure. Spain's commitment to 5G development is evident through significant investments, such as the €484 million contribution to the 5G infrastructure fund in November 2022, aimed at deploying networks in smaller cities. The EdgeConneX Barcelona edge data center, positioned in close proximity to customers and scalable to meet future needs, plays a crucial role in supporting cloud, content, and network providers with carrier-neutral connectivity.

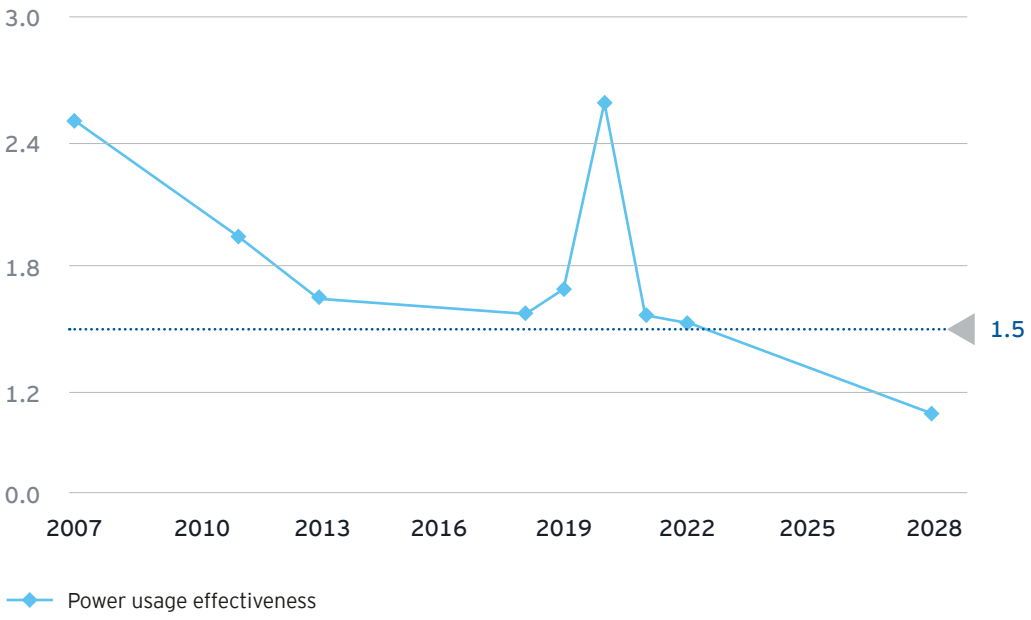
In conclusion, the integration of edge data centers with 5G infrastructure in Spain represents a strategic leap forward, enabling real-time data processing and addressing the critical need for high-speed, low-latency data transmission in today's digital landscape.

Growing Interest in Liquid Cooling Technologies and Hyperconverged Infrastructure

Liquid cooling, an innovative method for managing heat generated by IT equipment using liquid-based solutions like water or specialized coolants, is emerging as a major trend in the data center industry. It offers higher efficiency and thermal performance compared to traditional air cooling. Given that cooling comprises roughly 40% of a data center's energy consumption, efficient cooling is imperative. Liquid cooling enables data centers to maintain consistent temperatures, allowing for higher power densities and improved overall performance.

While initial adoption has been relatively slow due to the upfront investment and complexities involved, industry experts foresee increased interest in liquid cooling technologies in the coming years. Full-immersion cooling, a type of liquid cooling that submerges servers in a coolant, offers even greater efficiency and thermal performance, managing heat densities exceeding 100 kilowatts and boosting CPU performance by up to 40%. Hyperscalers, such as prominent cloud service providers, are expected to integrate liquid cooling into their data centers strategically.

Figure 32 **Power usage effectiveness**



Source: EY.

Power usage effectiveness (PUE) is a metric that indicates the proportion of power consumed by the computing equipment in a data center compared to its overall energy usage.

The introduction of cooling technologies could help to lead PUE toward 1: the closer PUE is to 1, the more efficient the data center's power usage. However, implementing liquid cooling requires a complete redesign of data center infrastructure, posing challenges in chip packaging, server form factors, building layouts, materials, and design. Collaborative efforts across the value chain are crucial to surmount these challenges and expedite technology adoption.

Hyperconverged infrastructure (HCI) solutions have emerged as a key trend in the data center market, offering a unified platform that integrates compute, storage, and networking resources. This integrated approach simplifies management, reduces complexity, and enhances operational efficiency for data center deployments.

The growing interest in HCI stems from its ability to streamline management and improve scalability. By consolidating resources into a single platform, HCI eliminates the need for separate management interfaces and simplifies resource provisioning and deployment. This agility and flexibility enable organizations to swiftly adapt to evolving business needs.

Moreover, HCI solutions are evolving to incorporate emerging technologies such as artificial intelligence and automation. These advancements automate routine tasks, optimize resource utilization, and empower data center operators to focus on strategic initiatives rather than routine maintenance. HCI's suitability for edge computing environments is another driving factor. As distributed computing demand rises, flexible and scalable infrastructure solutions are essential for edge deployments. HCI provides a cost-effective way to deploy compute and storage resources at the edge, improving application performance by processing data closer to the source.

Despite its benefits, HCI implementation poses challenges, including upfront costs, potential vendor lock-in, and setup complexity. Organizations must carefully evaluate their needs and weigh the benefits against challenges before adopting HCI.

To summarize, liquid cooling is poised to become a vital element of data center design, offering higher efficiency and thermal performance. Despite initial investment considerations, the long-term benefits make it an attractive choice for data center operators seeking to optimize energy efficiency and performance. At the same time, HCI offers a compelling solution for organizations seeking to simplify management, improve scalability, and enhance operational efficiency in their data center environments. By integrating compute, storage, and networking resources into a unified platform, HCI optimizes resource utilization, lowers operational costs, and meets the growing demands of modern data center deployments.

1,800MW

2.3. What is the expected trajectory of the capacity of the Spanish data center market?

Data centers in Spain are commonly owned and managed either by large corporations like cloud providers, financial institutions, or telecommunication companies, or by specialized colocation firms that rent out space and offer network capabilities, power, and cooling systems to maintain server temperature. Major players include Equinix or Interxion, providing colocation and cloud solutions.

The national spectrum of colocation data centers, excluding those owned by major hyperscalers like Google, IBM, and Microsoft, includes up to 114 facilities. The industry is divided between retail and wholesale players, primarily serving metropolitan areas such as Madrid and Barcelona, as well as emerging hubs like Bilbao. Wholesale operators dominate the market, with projections estimating over 1,800 MW of capacity by 2030. Retail operators, comprising 80 facilities, offer customized services to smaller businesses.

Additionally, 15 Spanish companies operate corporate data centers in Madrid and Barcelona, dominated by corporations operating in the financial sector.

Market Supply and Competitive Landscape

The data center market in Spain has undergone steady growth in recent years, fueled by the increasing demand for digital services, particularly cloud computing. Major players such as Equinix or Interxion offer a wide range of services, from colocation to managed hosting and cloud services.

Spain's colocation data center landscape comprises 114 facilities, from which 99 are existing data centers and 15 are planned data centers, predominantly located in major urban centers like Madrid and Barcelona, alongside emerging hubs like Bilbao and Aragon. These facilities can be split into retail and wholesale data centers, with retail data centers providing colocation and hosting services directly to end-users, focusing on customization and flexibility to meet the specific needs of small and medium-sized businesses.

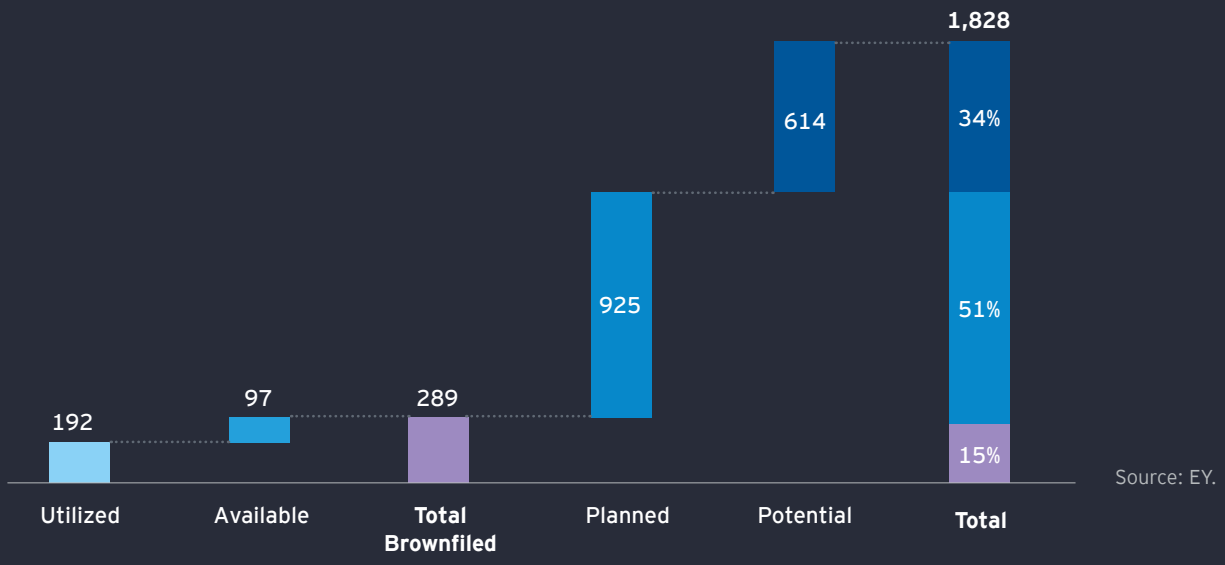
In contrast, wholesale data centers offer large-scale space and processing capacity to commercial clients, including cloud service providers and large enterprises, offering standardized services at competitive prices. Wholesale data centers appeal to organizations with substantial data processing needs, offering scalable and reliable infrastructure solutions without the burden of facility management.

Wholesale operators dominate the market, with projections estimating over 1,800 MW of capacity by 2030. Retail operators, comprising 80 facilities, offer customized services to smaller businesses.

Retail operators offer services like rack space, power, cooling, and network connectivity on a smaller scale compared to larger enterprises. Spain has 80 retail colocation data centers, with 100MW of actual capacity, aiming at over 150 MW by 2030.

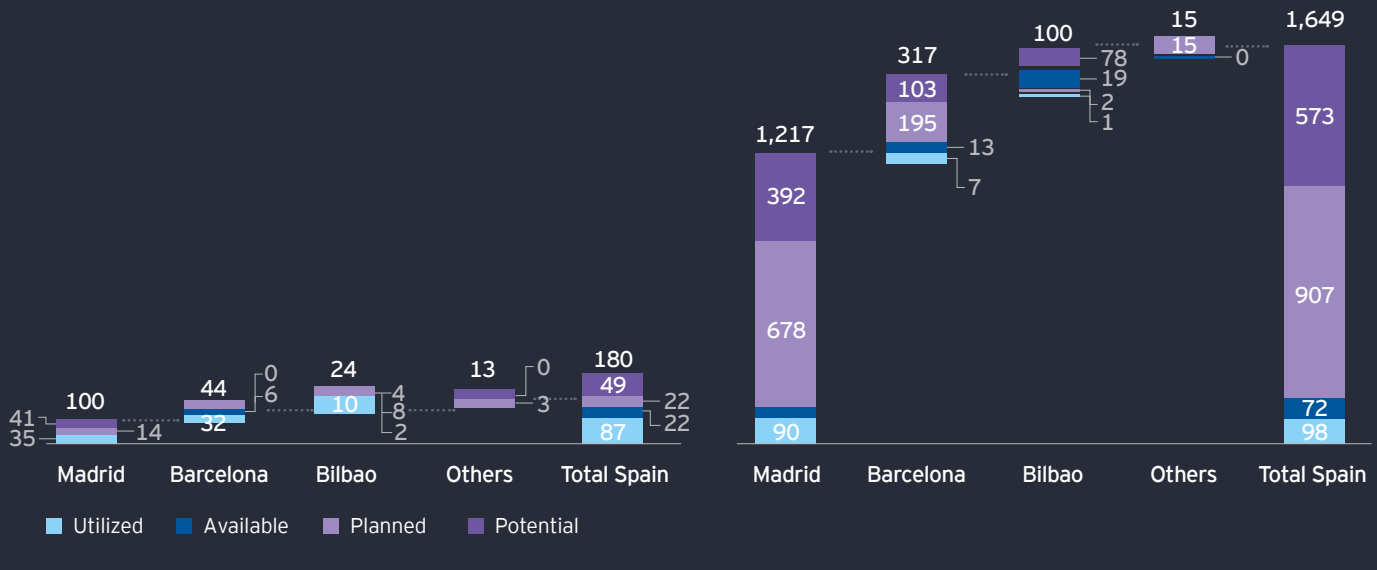
Wholesale operators provide large-scale colocation solutions and are leading the Spanish market. Spain has 34 wholesale colocation data centers (22 existing data centers and 12 planned) with 150 MW of actual capacity, aiming at over >1,600 MW by 2030. Madrid's data center market is experiencing rapid growth and competitiveness, with 20 players operating in the region. Barcelona is also expanding rapidly due to its strategic location appealing to businesses in the Mediterranean and Western Europe. Other regions like Bilbao and Valladolid also have wholesale operators, with major players including Equinix, EdgeConnex, Digital Realty, Data4 and Nabiax.

Figure 33 **Market supply by availability, Spain** (MW)



Source: EY.

Figure 34 **Retail and wholesale market supply by geography** (MW)



Source: EY.

Corporate Data Centers in Spain

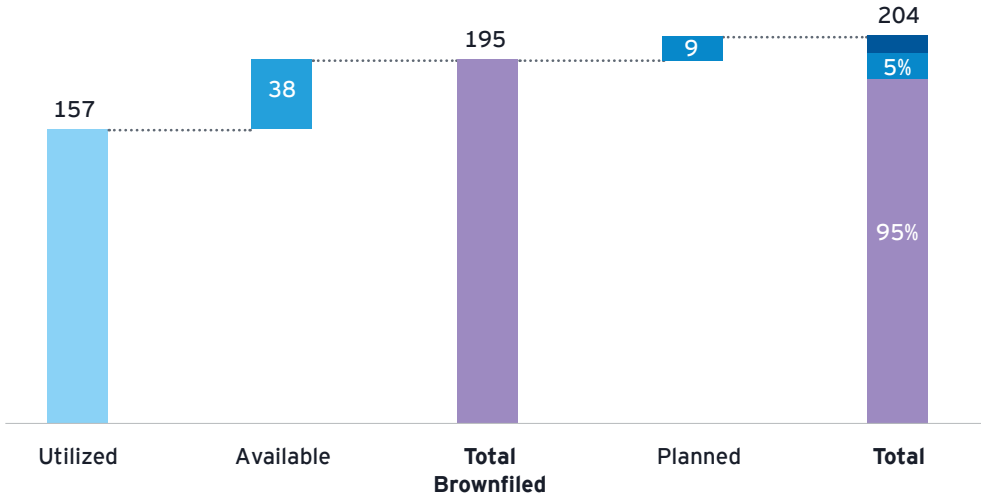
The presence of corporations with data centers in Spain is concentrated among 14 Spanish firms that leverage their own data centers primarily as hubs for personal data. These companies collectively operate 38 data centers across Spain, predominantly in Madrid and Barcelona. Currently, corporate data centers in Spain have a total brownfield capacity of 204 MW, with 157 MW (80%) in use and 38 MW (20%) available. Additionally, some data centers are under construction, such as the data centers being built by MasOrange, which will provide a total of 9 MW.

Due to the growing importance of data for business, most data centers are strategically located near their headquarters, with Madrid hosting 9 operational data centers (across Santander and BBVA). Barcelona follows closely with 7 data centers, positioning it as the second province with the highest data center count, while the Basque Country ranks third with 3 centers.

The financial industry dominates the corporate data center landscape in Spain, with leading banks such as Santander, BBVA, Sabadell, CaixaBank, Kutxabank, and Abanca maintaining a significant presence. Retail players, such as Inditex, Mercadona, and El Corte Inglés, also have a significant presence in the territory, alongside notable telecommunications operators, represented by companies like MasOrange.

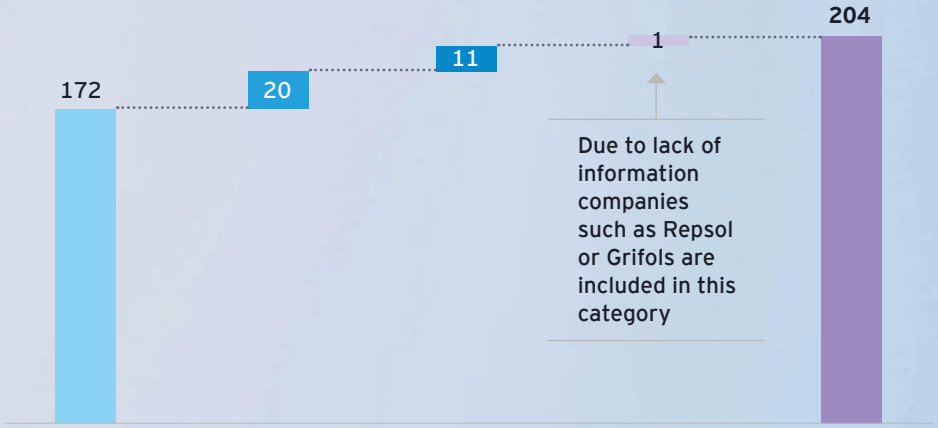
Among the top-ranking companies in terms of capacity, BBVA stands out with two data centers in Madrid, boasting a combined total of 53 MW, closely followed by CaixaBank with 48 MW, and Santander with 37 MW.

Figure 35 **Market supply by availability, Spain** (mw)



Source: EY.

Figure 36 Capacity of corporate data centers by sector



	Financial	Retail	Telecom.	Other	**Total**
# of DCs	14	7	8	7	**36**
# of companies	5	3	1	5	**14**

Source: EY.

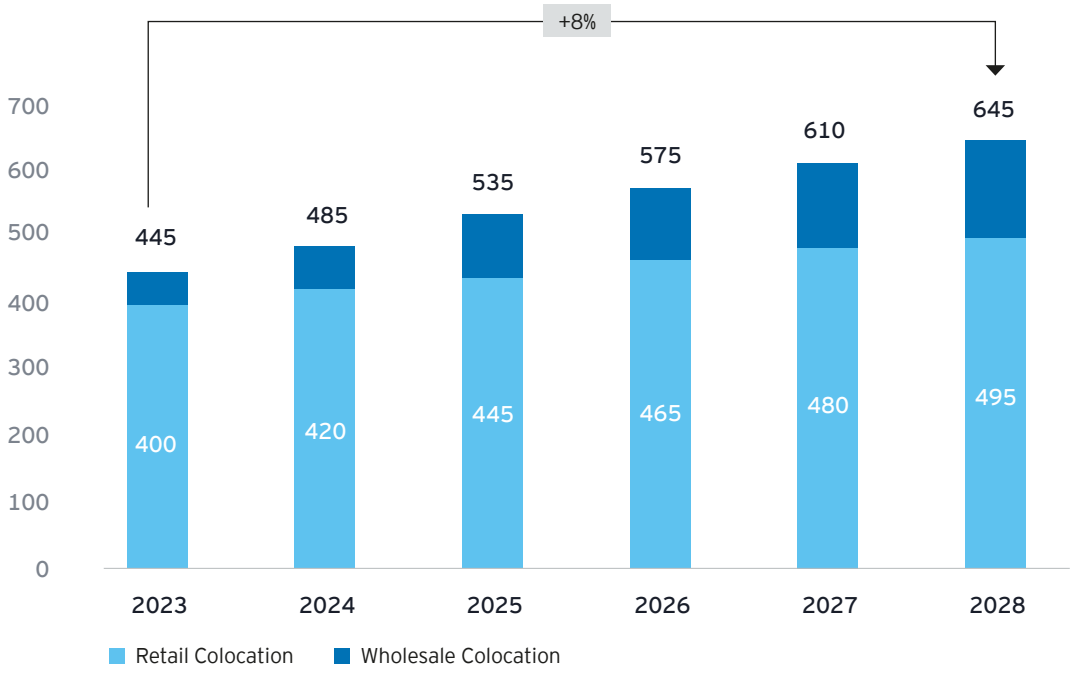
2.4. What investment opportunities are available in the data center industry?

Spain's pivotal role in the expansion of the industry is underscored by increasing investment and a rising number of data center transactions, reflecting the growing importance of robust data infrastructure in the country's evolving digital landscape and its integration into the global business ecosystem.

Madrid is at the forefront of the Spanish market, boasting an average occupancy rate of approximately 70% across its existing data centers, with major providers operating at around 80% occupancy. Meanwhile, Barcelona is gearing up for rapid capacity expansion in the near future.

Colocation demand in Spain is expected to surge, driven by the expansion of cloud service providers, growth in content providers and telecom operators enhancing 5G capabilities, and limitations in primary European markets leading to shifts in workloads. Cloud services are expected to dominate, accounting for over 70% of market share.

Figure 37 **Retail vs wholesale colocation revenue forecasted in Spain**



Source: EY.

The colocation data center industry in Spain is set to experience significant revenue expansion, with revenues projected to rise from $445 million in 2023 to $645 million by 2028, making for a noteworthy CAGR of 8%. Retail colocation dominates the market, accounting for 90% of revenues in 2023, with a projected CAGR of 4.34% from 2023 to 2028. Wholesale colocation revenues are anticipated to witness remarkable growth, with a CAGR of 27.42% until 2028.

The investment required for each data center varies depending on characteristics such as MW capacity, location, and size. CapEx typically ranges between €6 million and €10 million per MW of capacity, but advancements in energy access capabilities or technologies could potentially reduce these expenses by 15% to 30%. OpEx is estimated at €1 million per MW of capacity, covering expenses such as salaries, insurance, security, and technology provisions.

EBITDA margins from colocation center rentals in Spain excluding the energy pass through averages between 50% to 60% annually. Tenants tend to stay in data centers with a churn rate for edge data centers of 3% to 5%.

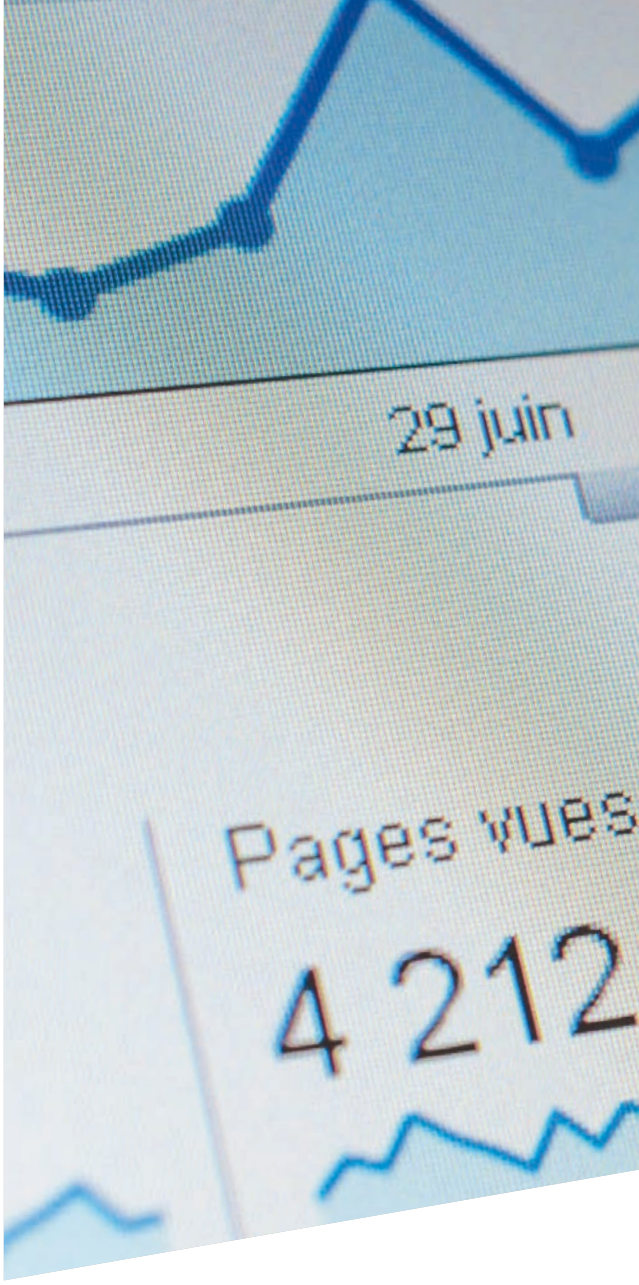
In the past few years, there has been a remarkable surge in transaction activities across the global market. In 2021, 209 deals were recorded, amounting to a collective value surpassing $48 billion. This represented a significant increase of nearly 40% compared to the preceding year, when deals totaled $34 billion. The momentum persisted into the first half of 2022, with 87 transactions reaching a combined value of an impressive $24 billion.

In recent years, data center transactions in Spain have garnered significant attention, with notable deals involving technology companies with a dedicated focus on data centers as a service, and private equity firms, which are prominent players in this type of acquisitions. The average Enterprise Value to EBITDA multiple typically ranges from 20x to 30x, reflecting the robust valuation landscape within the sector. Each data center is being transacted between €50 million to €90 million, depending on its specific characteristics.

Additionally, several players are exploring greenfield data center investments to capture market opportunities. For example, Iberdrola is seeking partners for a new joint venture aiming to provide 200 MW of data center capacity in Spain by 2030.

70%

Madrid is at the forefront of the Spanish market, boasting an average occupancy rate of approximately 70% across its existing data centers, with major providers operating at around 80% occupancy.



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3

The Power of Feedstock: Fueling the Future with Biogas

3.1. Introduction

Current context

Biomethane is one of the naturally occurring gases poised to play a prominent role in the decarbonization process currently underway in the European Union. The 2050 climate neutrality goals involve increasing renewable electricity production and reducing greenhouse gases. In this regard, biomethane positions itself as a strategic compound due to its characteristics: it is a renewable fuel capable of replacing more pollutant fuels, such as fossil fuels, and other renewable fuels, such as compost.

The uses of biomethane encompass the same range as fossil-origin natural gas, including electricity generation, heat generation for industrial processes and end consumers, and as fuel for EV/GV transport vehicles. While both electricity generation and transportation have renewable alternatives, biomethane has high potential to establish itself as a differentiating asset for heat generation in hard-to-abate industries such as metallurgy, cement and chemical industries. Moreover, sustainable alternatives such as electric boilers or green hydrogen either lack sufficient heating potential or are not yet developed enough for implementation. Additionally, biomethane could become a strong competitor in the decarbonization of the transport sector despite the expansion of electric transport.

The compatibility of biomethane with Spain's developed gas infrastructure significantly increases its expansion possibilities within the territory. Spain has a gas pipeline network exceeding 11,000 km, along with numerous storage locations, making the country one of the best regions in Europe for the development of biomethane. Furthermore, as will be detailed throughout the report, the large agricultural and livestock industry in Spain provides a vast availability of raw materials yet to be exploited.

The reuse of waste is another aspect where biomethane shows a competitive advantage over other compounds like natural gas. In this sense, the compound offers a dual value proposition: reducing carbon dioxide emissions resulting from the decomposition of organic waste (which does not occur in the anaerobic digestion process) and recovering the waste itself, generating value from refuse. These two factors act as a catalyst to renew the importance of the primary sector in Spain, increase employment opportunities, and attract investment in rural areas of the country.

Analysis Goals

There are several uncertainties or areas that require clarification in the biomethane sector. One is the availability of adequate and feasible feedstock in development regions, and the other concerns the expected market demand and the willingness of potential offtakers to pay. While EY is addressing demand questions in other analyses, the purpose of this analysis is to focus on the potential feedstock for biomethane. Specifically, it examines which sectors can provide feedstock and assesses accessibility across different regions of Spain. Granularity is key due to the logistical limitations of feedstock.

Furthermore, a secondary objective of this analysis is to demonstrate that the potential for biomethane in Spain remains underutilized. The country's characteristics, including abundant raw materials and infrastructure ready to meet demand, position Spain as a strategic generation hub at the European level.

The demand for natural gas in Spain reached 325.4 TWh (approximately 29.4 billion cubic meters) in 2023. Despite the increasing strength of renewable generation, the decommissioning process of fossil energies in which the country is immersed makes a drastic reduction in the generation of electricity and heat by thermal technologies unthinkable. On the other hand, the production targets of the National Integrated Energy and Climate Plan (PNIEC) 2023-2030 establish the generation of 20 TWh of biogas (equivalent to less than 2% of biomethane injected into the grid), in the low range of the 2018 IDAE's assessment[2] (Institute for Energy Diversification and Saving), defining the biomethane potential for Spain in the range between 20 and 34 TWh.

This would be equivalent to 6.1% of the gas demand of 2023. Additionally, there is also a contrast with the requirements at the European level set out in the REPowerEU plan, through which Europe commits to producing 35 billion cubic meters (bcm) of biomethane annually by 2030 (equivalent to 387 TWh), representing a tenfold increase in current production. The differences in targets indicate a lack of alignment between the Spanish and European governments, caused by an insufficiently ambitious assessment of Spain's biomethane potential.

20-34 TWh

The production targets of the PNIEC 2023-2030 establish the generation of 20 TWh of biogas in the low range of the 2018 IDAE's assessment, defining the biomethane potential for Spain in the range between 20 and 34 TWh.

[2] Mention in Cámara Comercio de España Report. *El biometano, aliado de la economía circular y la descarbonización*.

Table 1 **Spain vs Europe Biogas objectives for 2030 stablished in 2023**

	Spain (2030)	European Union (2030)
Energy generation [TWh]	20	387
Consumption - Billion Cubic Meters (bcm)	2	35

Source: EY Parthenon.

Considering this situation, a detailed study is proposed to quantify the possibilities of biomethane in Spain in terms of potential energy, accessible feedstock and available feedstock (distinction for non-demanded and demanded feedstock). Additionally, the potential of biomethane has been assessed with detailed granularity at the provincial level due to the complexity of transporting the raw material.

Furthermore, the methodology used considers the major sources of available and accessible raw materials for biogas production (livestock, animal, and plant matter). The aim is to reasonably quantify the production possibilities of biomethane in Spain and identify the main strategic generation locations to facilitate its implementation and investment decisions.

387 TWh

There is also a contrast with the requirements at the European level set out in the REPowerEU plan, through which Europe commits to producing 35 billion cubic meters (bcm) of biomethane annually by 2030 (equivalent to 387 TWh.

3.2. Analysis Methodology

Considerations

Three types of biomethane sources have been considered for this study: livestock, animal, and plant.

Excluding forest biomass, landfills, FORSU (Organic Fraction of Urban Solid Waste), and WWTP (Waste Water Treatment Plants), certain sources were deemed unprofitable due to access difficulties or the involvement of municipal projects. Therefore, this study focuses on the primary sector, excluding forestry as previously mentioned.

An additional characteristic of this study is its granularity, not only by province but also by waste type. This detailed approach allows for the identification of specific feedstock providers in each region in subsequent steps. The waste types have been classified into 26 categories and 124 subcategories, structured as follows:

Table 2 **Categorization of waste feedstock**

Livestock and animal waste		Plant waste	
Category	**#**	**Category**	**#**
Pig slurry	3	Cereals withdrawals	6
Cow dung	3	Vegetable withdrawals	16
Poultry manure	2	Citrus withdrawals	3
Remains of other species	3	Withdraws non-citrus fruit trees	7
Meat slaughterhouse by-products	7	Non-compliant vegetables	16
Fish waste	3	Non-compliant tubers	1
WWTPI sludge - fish	3	Citrus non-compliant	3
		Non-compliant non-citrus fruit	7
		Vegetables processing	16
		Processing tubers	1
		Citrus processing	3
		Non-citrus fruit processing	7
		Bagasse - Brewing industry	1
		Alperujo 2 Phases	1
		Alpechín 3 Phases	1
		Wine industry waste	2
		Cider industry waste	1
		Waste from the sugar industry	2
		Cereal straw	6

Source: EY Parthenon.

To calculate the potential biomethane production in Spain, it is necessary to consider various types of feedstock. This includes livestock waste, which requires analyzing the number of livestock per province and the corresponding excrement production. Additionally, the quantity of livestock processed in slaughterhouses, categorized by type and province, must be considered. Similarly, the kilograms of fish and shellfish caught or produced, categorized by species and province, are crucial. For plant-based feedstock, an assessment of the kilograms of plants produced, segmented by province and type of crop, is also required.

Finally, with regard to the regions covered by the study, the 50 provinces of the Spanish map have been considered, as well as the cities of Ceuta and Melilla.

Analysis Methodology

To extract energy from biogas in Spain, we have chosen anaerobic digestion as the primary method. This commercially widespread technique is effective for producing biogas from easily degradable feedstocks, such as livestock waste, agri-food waste, and sewage sludge. Additionally, we consider gasification, a developing technology that converts waste that is difficult to degrade. These methods are essential for maximizing the energy potential from various types of waste.

Before delving into the methodology, it is important to understand a few key concepts to transform from waste resource to the biomethane potential. Total Solids (TS) refer to the amount of matter remaining after drying or evaporation at 105ºC. Volatile Solids (VS) are the portion of total solids that, when subjected to combustion at approximately 550ºC, transform into CO_2 and H_2O, indicating the amount of organic matter present. Biogas potential represents the amount of biogas that can be extracted from the volatile solids in the feedstock. CH_4 content represents the amount of CH_4 contained in the biogas produced from waste. Lastly, the High Heating Value (HHV) measures the total energy released when a substance is burned in an oxygenated atmosphere.

The procedure for calculating the potential energy in Spain involves several steps. First, we need to determine the amount of substrate, which is the existing usable raw material. For livestock, this involves calculating the substrate based on the number of head of livestock and their waste production. For animal waste from slaughterhouses, it involves measuring the waste produced and applying a direct coefficient. Similarly, fish production waste and vegetable crop production are calculated using their respective direct coefficients and production quantities.

This comprehensive assessment ensures that we account for all potential feedstock sources.

To determine biogas generation, we calculate the substrate and then multiply it by the percentage of total solids, volatile solids and biogas potential. This gives us the total biogas produced per year. To convert this biogas into accessible energy, we need to know the methane content and the calorific value of the biogas. By applying these factors, we can calculate the total energy generated annually. This process allows us to estimate the energy potential from biogas, providing a clear picture of the renewable energy resources available in Spain.

105ºC

Total Solids (TS) refer to the amount of matter remaining after drying or evaporation at 105ºC.

Accessibility and Availability Coefficient

To estimate the potential of biogas generation in Spain, it is crucial to consider that not all existing feedstock in the sector is accessible or available for use as fuel. Therefore, two coefficients have been utilized: the accessibility coefficient and the availability coefficient.

Accessibility potential refers to the amount of waste that could potentially be used for biogas generation without considering alternative uses. This quantity is adjusted to exclude waste that cannot be utilized due to legislative constraints, production processes, or the characteristics of intensive farming. It varies depending on the different types of waste. For livestock, it accounts for waste that cannot be collected due to legislation or extensive farming practices that make collection unfeasible.

For animal waste, specifically dairy and fish, there are no significant limitations considered, whereas for meat waste, only by-products not suitable for human consumption and those exempt from SANDACH legislation are included (animal by-products not intended for human consumption). In the case of plant waste, no accessibility constraints are considered, resulting in a coefficient of 1, meaning all plant waste is considered accessible, due to the categories considered in the analysis. This comprehensive approach ensures a realistic assessment of the waste that can be feasibly collected for biogas production.

The availability potential is a further reduction of the accessibility potential, considering alternative uses of the waste in each category. For livestock waste, this includes uses such as compost production, livestock feed, or direct application in agriculture, meaning not all accessible waste is earmarked for biomethane production, and the final destination would depend on the incentives for the farmer.

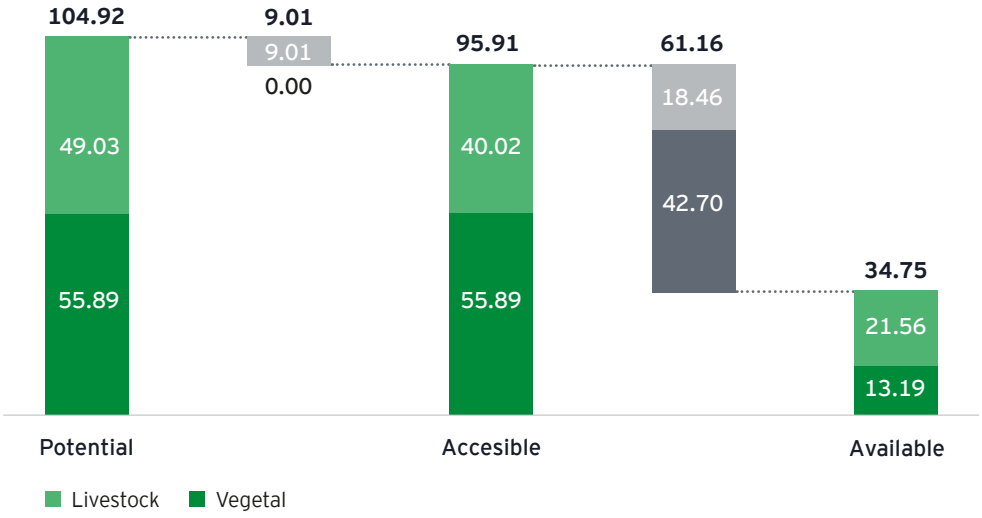
Animal waste, particularly dairy and fish waste, has few alternative uses and therefore higher availability coefficients compared to other categories. Conversely, plant waste has a wide range of alternative uses, such as the production of bioplastics or agricultural fertilizers. For instance, alperujo (olive pomace), a type of vegetable waste, has a low availability coefficient of 0.1 due to its extensive alternative applications that could be economically viable (i.e., highly linked to olive oil prices) and still, with some uncertainties in the Spanish regulation, due to potential use as food under Annex IX a of the Directive 2018/2001.

The available potential distinction ensures a more accurate estimation of the waste available for biogas generation after considering other potential uses.

3.3.
Outcomes of the Analysis

Overall results and key figures for potential, accessible and available

Figure 38



Source: EY Parthenon.

To start with this results section, aggregated values of accessible and available energy from animal and plant sources are presented:

Table 3 **Potential Energy: Livestock and plant potential energy in Spain**

Livestock Accessible Energy (TWh)	Plant Accessible Energy (TWh)	Total Accessible Energy (TWh)
49.03	55.89	104.92

Table 4 **Accessible Energy: Livestock and plant accessible energy in Spain**

Livestock Accessible Energy (TWh)	Plant Accessible Energy (TWh)	Total Accessible Energy (TWh)
40.02	55.89	95.91

Table 5 **Available Energy: Livestock and plant available energy in Spain**

Livestock Accessible Energy (TWh)	Plant Accessible Energy (TWh)	Total Accessible Energy (TWh)
21.56	13.19	34.75

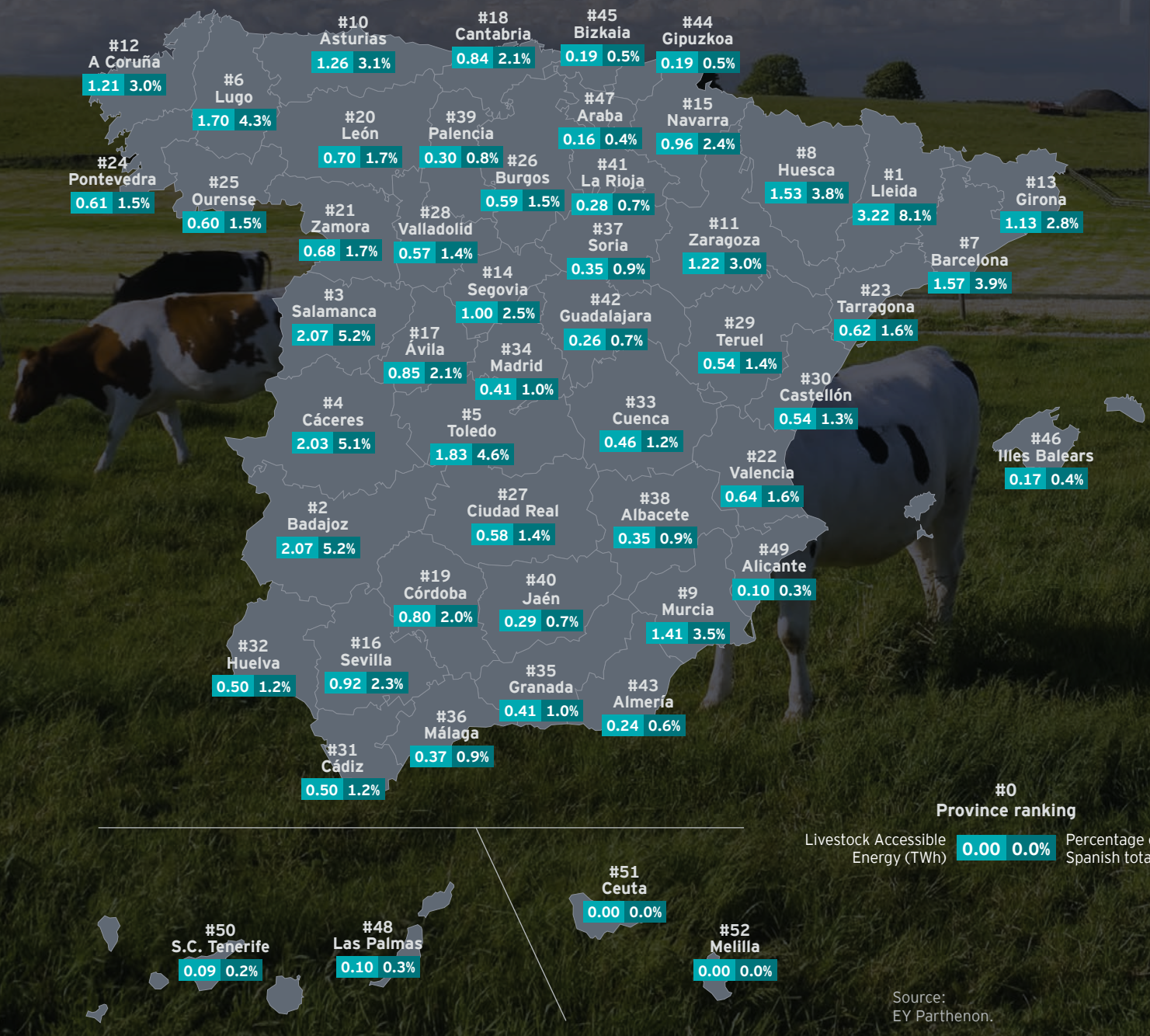
Source: EY Parthenon.

As a first conclusion of the analysis, it is observed that Spain's significant potential in biomethane production aligns closely with the objectives outlined in the PNIEC (National Integrated Energy and Climate Plan) and IDAE (Institute for Energy Diversification and Saving). With accessible energy totaling 95.91 TWh, Spain exceeds the PNIEC's target of 20 TWh by 2030, demonstrating ample capacity to contribute significantly to renewable energy goals. Furthermore, this meets the target set by IDAE in the "Hoja de Ruta del Biogás," which foresaw a range between 20 and 34 TWh including all types of waste. This study presents more optimistic figures due to the detailed granularity of the types of waste with potential.

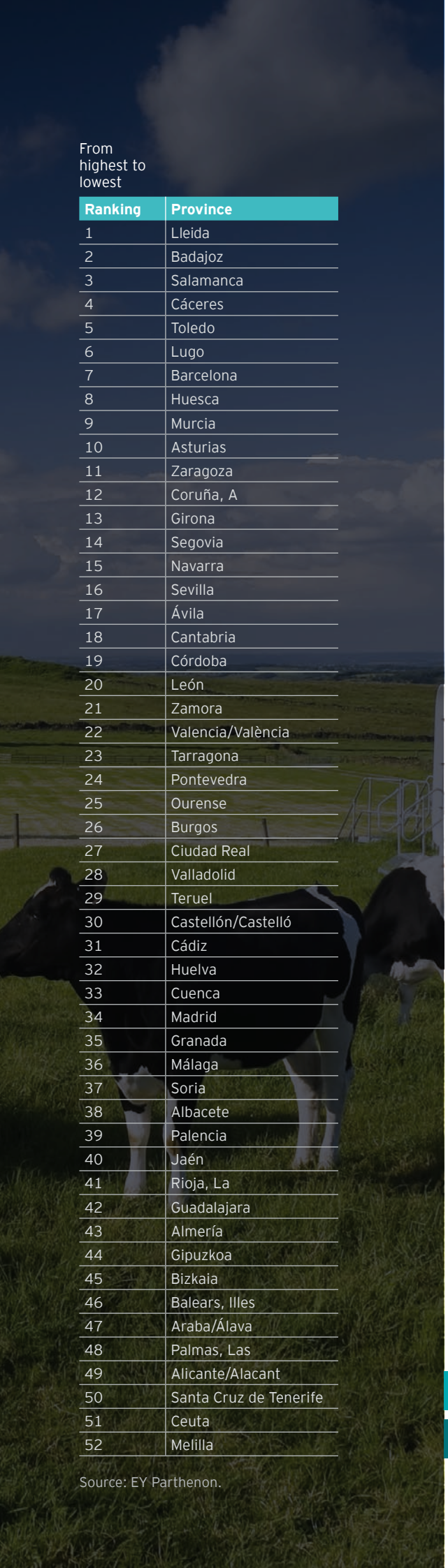
Results of Accessible and Available Energy by Province for Agriculture and Livestock

The following tables show the results of accessible energy of animal and vegetable origin for each of the 50 provinces and the two autonomous cities of Ceuta and Melilla, as well as the overall results for the country as a whole. After each of the tables, explanatory notes are provided to explain the rationale behind these results. Finally, the main conclusions drawn from the analysis are described:

Figure 38 **Accessible energy of animal origin by province**



Source:
EY Parthenon.



From highest to lowest

Ranking	Province
1	Lleida
2	Badajoz
3	Salamanca
4	Cáceres
5	Toledo
6	Lugo
7	Barcelona
8	Huesca
9	Murcia
10	Asturias
11	Zaragoza
12	Coruña, A
13	Girona
14	Segovia
15	Navarra
16	Sevilla
17	Ávila
18	Cantabria
19	Córdoba
20	León
21	Zamora
22	Valencia/València
23	Tarragona
24	Pontevedra
25	Ourense
26	Burgos
27	Ciudad Real
28	Valladolid
29	Teruel
30	Castellón/Castelló
31	Cádiz
32	Huelva
33	Cuenca
34	Madrid
35	Granada
36	Málaga
37	Soria
38	Albacete
39	Palencia
40	Jaén
41	Rioja, La
42	Guadalajara
43	Almería
44	Gipuzkoa
45	Bizkaia
46	Balears, Illes
47	Araba/Álava
48	Palmas, Las
49	Alicante/Alacant
50	Santa Cruz de Tenerife
51	Ceuta
52	Melilla

Source: EY Parthenon.

As conclusions drawn from the data in the previous table, the following can be stated:

- **More than 50% of the accessible energy from animal sources is concentrated in 12 provinces:** Lleida, Badajoz, Salamanca, Cáceres, Toledo, Lugo, Barcelona, Huesca, Murcia, Asturias, Zaragoza and A Coruña.

- **The top 5 provinces, with accessible energy greater than 1.75 TWh**, are the following:

Lleida

High volume of livestock farming, focused on cattle, sheep and pigs. This province is known for its high-quality meat production and dairy products. Out of the 3.22 TWh of accessible energy, 1.28 TWh is considered available (58%).

Badajoz

Livestock farming in centers around pigs and sheep, taking advantage of the extensive pastures and "dehesas" (wooded pasturelands) that are ideal for raising these animals. Out of the 2.07 TWh of accessible energy, 1.10 TWh is considered available (53%).

Salamanca

Is renowned for its extensive cattle and pig farming. This province is well known for its production of famous Iberian meats. Out of the 2.07 TWh of accessible energy, 1.07 TWh is considered available (52%).

Cáceres

Like Badajoz, livestock farming in Cáceres focuses on pigs and sheep, utilizing natural pastures and "dehesas". Out of the 2.03 TWh of accessible energy, 1.02 TWh is considered available (50%).

Toledo

Livestock farming in Toledo includes both sheep and cattle, with a focus on high-quality meat production. Out of the 1.83 TWh of accessible energy, 1.00TWh is considered available (55%).

40.03 **Total** Livestock Accessible Energy (TWh)

100% **Total** Percentage

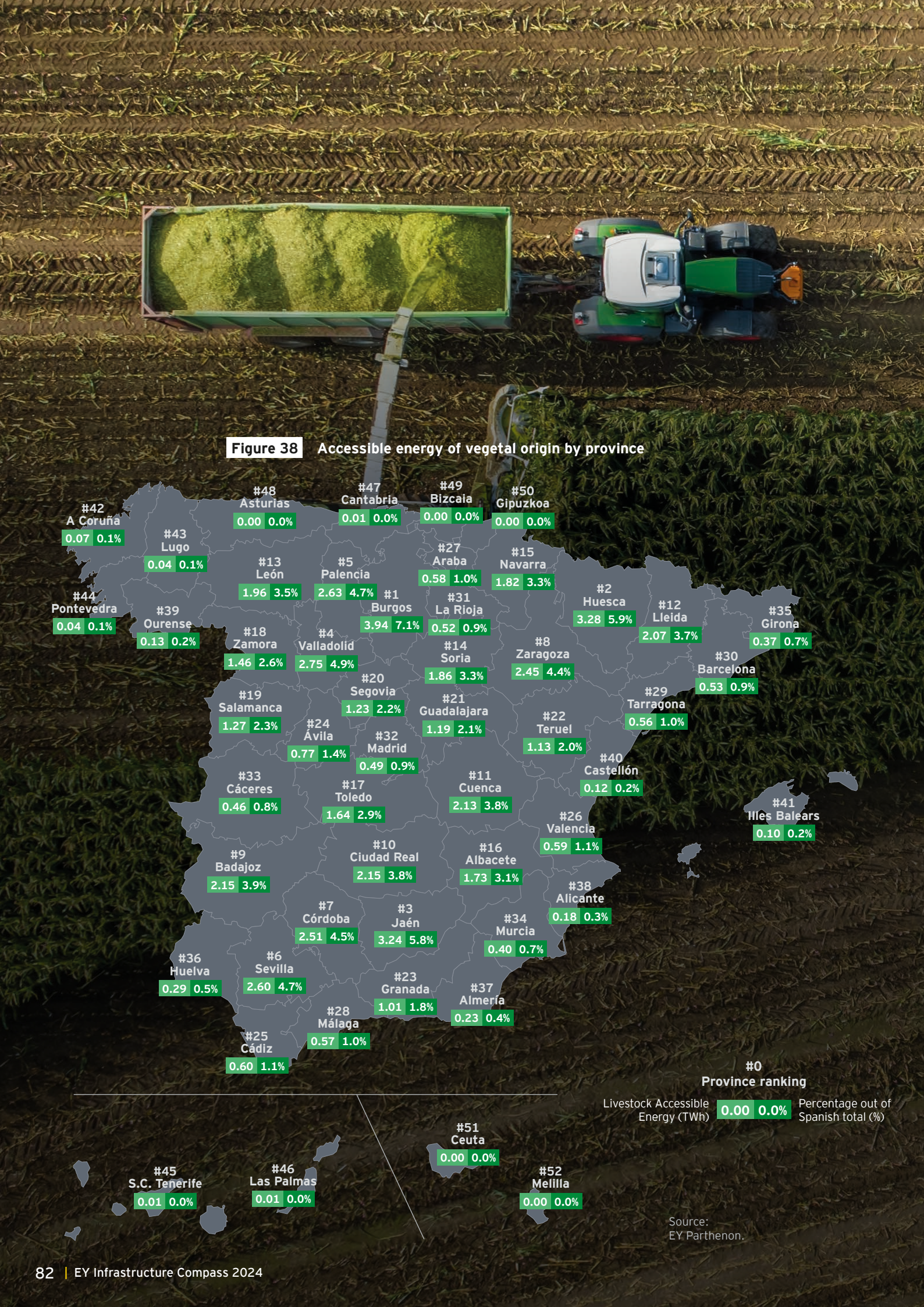


Figure 38 Accessible energy of vegetal origin by province

Source:
EY Parthenon.

From highest to lowest

Ranking	Province
1	Burgos
2	Huesca
3	Jaén
4	Valladolid
5	Palencia
6	Sevilla
7	Córdoba
8	Zaragoza
9	Badajoz
10	Ciudad Real
11	Cuenca
12	Lleida
13	León
14	Soria
15	Navarra
16	Albacete
17	Toledo
18	Zamora
19	Salamanca
20	Segovia
21	Guadalajara
22	Teruel
23	Granada
24	Ávila
25	Cádiz
26	Valencia/València
27	Araba/Álava
28	Málaga
29	Tarragona
30	Barcelona
31	Rioja, La
32	Madrid
33	Cáceres
34	Murcia
35	Girona
36	Huelva
37	Almería
38	Alicante/Alacant
39	Ourense
40	Castellón/Castelló
41	Balears, Illes
42	Coruña, A
43	Lugo
44	Pontevedra
45	Santa Cruz de Tenerife
46	Palmas, Las
47	Cantabria
48	Asturias
49	Bizkaia
50	Gipuzkoa
51	Ceuta
52	Melilla

Source: EY Parthenon.

- **Around 50% of the accessible energy from plant sources is concentrated in 10 provinces:** Burgos, Huesca, Jaén, Valladolid, Palencia, Sevilla, Córdoba, Zaragoza, Badajoz and Ciudad Real

- **The top 7 provinces, with accessible energy greater than 2.5 TWh**, are the following:

Burgos

Has large expanses of land primarily dedicated to extensive agriculture. Cereals such as wheat, barley and rye are grown in vast open fields. Out of the 3.94 TWh of accessible energy, 0.89TWh is considered available (23%).

Huesca

Features a combination of extensive and intensive agriculture. Extensive cultivation focuses on cereals like maize and barley, while intensive agriculture includes fruits such as peaches, cherries, etc. Out of the 3.28 TWh of accessible energy, 0.74 TWh is considered available (23%).

Jaén

Predominantly involved in extensive agriculture, especially in the extensive olive groves that cover much of the landscape. Cereals like wheat and maize are also grown on significant acreage. Out of the 3.24 TWh of accessible energy, 0.77 TWh is considered available (24%).

Valladolid

Characterized by primarily extensive agriculture, with large areas dedicated to cereal crops like wheat and barley. Out of the 2.75 TWh of accessible energy, 0.64 TWh is considered available (23%).

Palencia

Practices primarily extensive agriculture, focusing on cereal crops like wheat, barley, and maize across expansive agricultural lands. Out of the 2.63 TWh of accessible energy, 0.60 TWh are considered available (23%).

Sevilla

Combines extensive and intensive agriculture, including a wide variety of crops, from citrus fruits like oranges and lemons to olive groves for olive oil production. Out of the 2.60 TWh of accessible energy, 0.66 TWh is considered available (25%).

Córdoba

Predominantly practices extensive agriculture with extensive olive groves for olive oil production. Cereal crops like wheat and maize are also grown in large areas. Out of the 2.51 TWh of accessible energy, 0.61 TWh is considered available (24%).

55.89 **Total** Livestock Accessible Energy (TWh)

100% **Total** Percentage

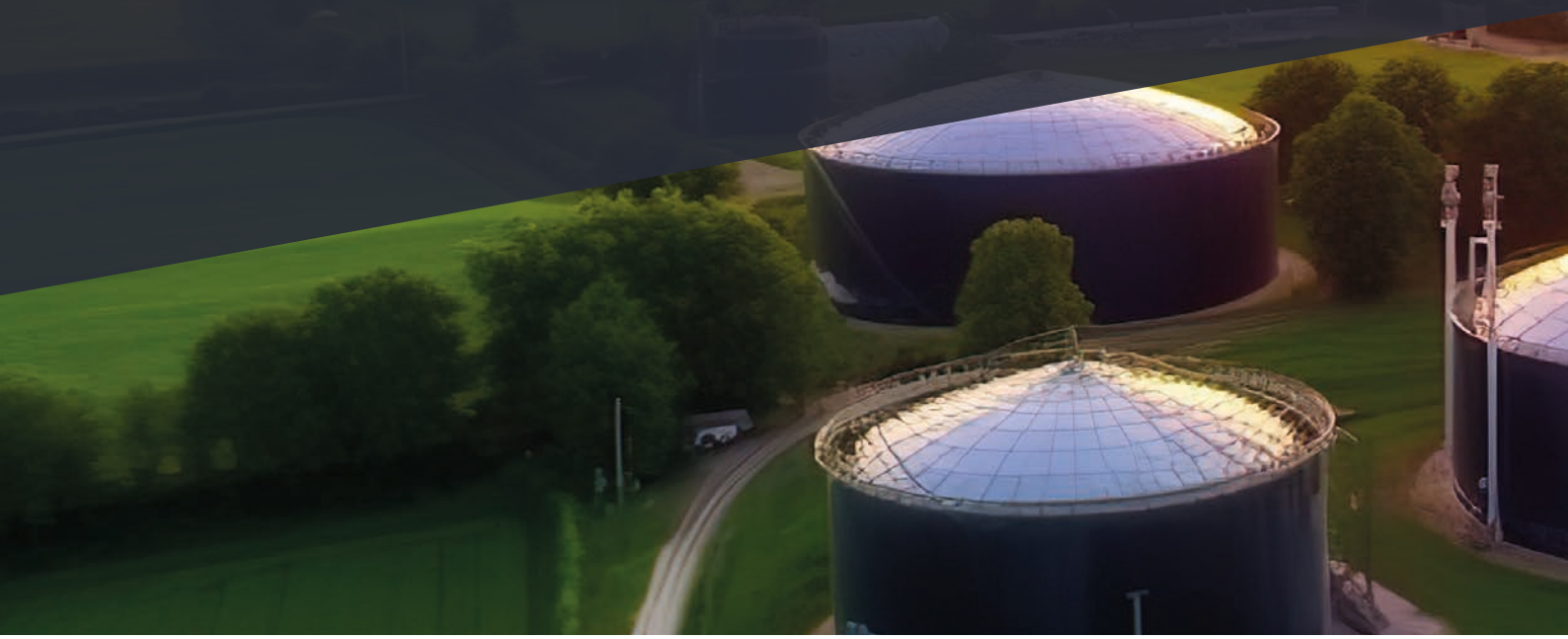
Top 10 Provinces and Type of Mix

The following table displays, for each of the provinces in the top 10, the total accessible energy, the breakdown by livestock and plant origin, and the percentage of each type to illustrate the mix at the provincial level in the most relevant areas.

Table 4 **Accessible Energy Top 10 Provinces**

Rank	Province	Accessible Energy (TWh)	Livestock Origin (TWh)	Plant Origin (TWh)	Livestock (in %)	Plant (in %)
1	Lleida	5.29	3.22	2.07	61%	39%
2	Huesca	4.82	1.53	3.28	32%	68%
3	Burgos	4.53	0.59	3.94	13%	87%
4	Badajoz	4.23	2.07	2.15	49%	51%
5	Zaragoza	3.67	1.22	2.45	33%	67%
6	Jaén	3.52	0.29	3.24	8%	92%
7	Sevilla	3.52	0.92	2.60	26%	74%
8	Toledo	3.47	1.83	1.64	53%	47%
9	Salamanca	3.34	2.07	1.27	62%	38%
10	Valladolid	3.32	0.57	2.75	17%	83%

Source: EY Parthenon.



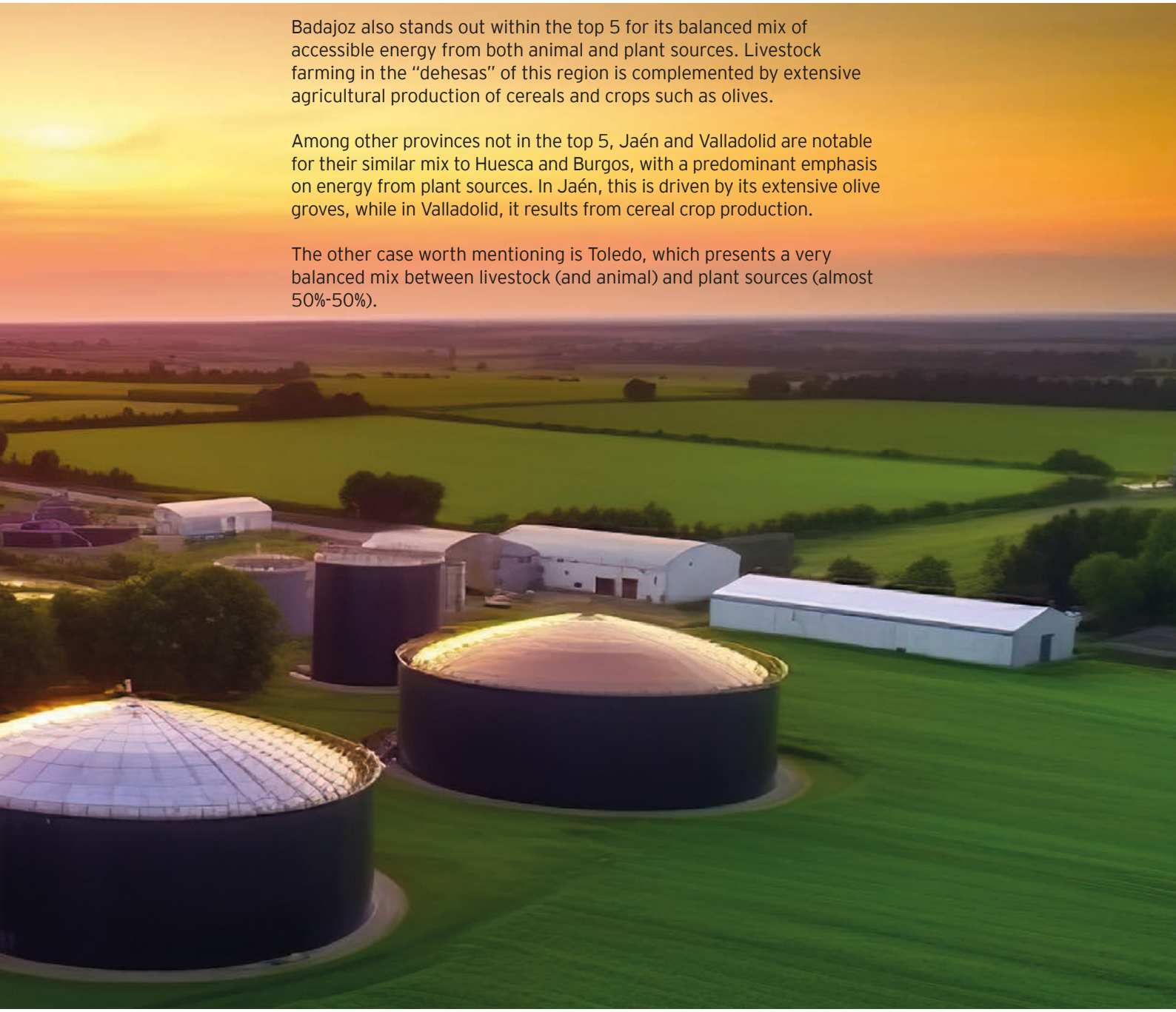
As shown in the table 4, the Spanish province with the most accessible energy is Lleida, with 5.29 TWh out of a national total of 95.92 TWh, representing 5.5%. This province stands out primarily for its accessible energy of animal origin, largely from pig farming, and significantly surpasses other provinces in the top 10. Lleida holds the leading position due to its animal-to-plant energy mix of 60% to 40%.

The provinces of Huesca and Burgos stand out for having relevant positions in the ranking thanks to their accessible energy of plant origin. In particular, in the case of Burgos, the mix is almost 90%-10% in favor of plant origin. Both provinces have a relevant production of cereals, especially Burgos with its extensive fields. Huesca also stands for its fruit production.

Badajoz also stands out within the top 5 for its balanced mix of accessible energy from both animal and plant sources. Livestock farming in the "dehesas" of this region is complemented by extensive agricultural production of cereals and crops such as olives.

Among other provinces not in the top 5, Jaén and Valladolid are notable for their similar mix to Huesca and Burgos, with a predominant emphasis on energy from plant sources. In Jaén, this is driven by its extensive olive groves, while in Valladolid, it results from cereal crop production.

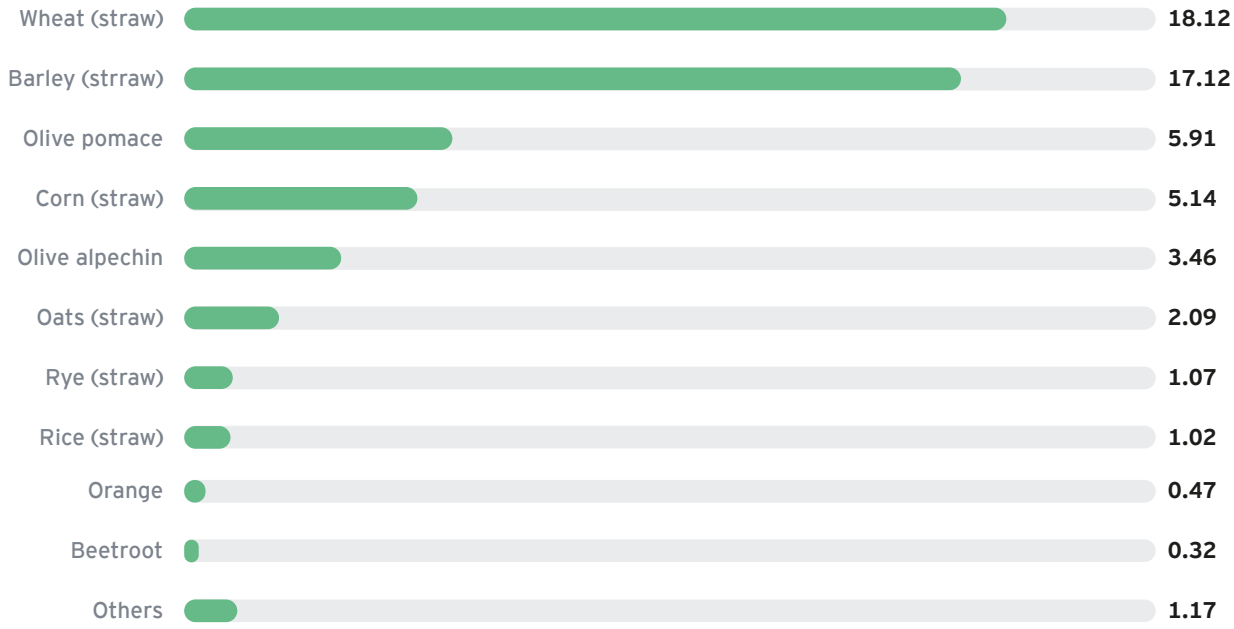
The other case worth mentioning is Toledo, which presents a very balanced mix between livestock (and animal) and plant sources (almost 50%-50%).



Top Types of Waste from Animal and Plant Sources

Among the main types of plant waste contributing to accessible biomethane energy, two types stand out: straw and other crop residues (80%) and olive pomace and similar waste (17%), as can be seen in the following chart.

Figure 39 **Top 10 plant-origin accessible energy** (TWh)



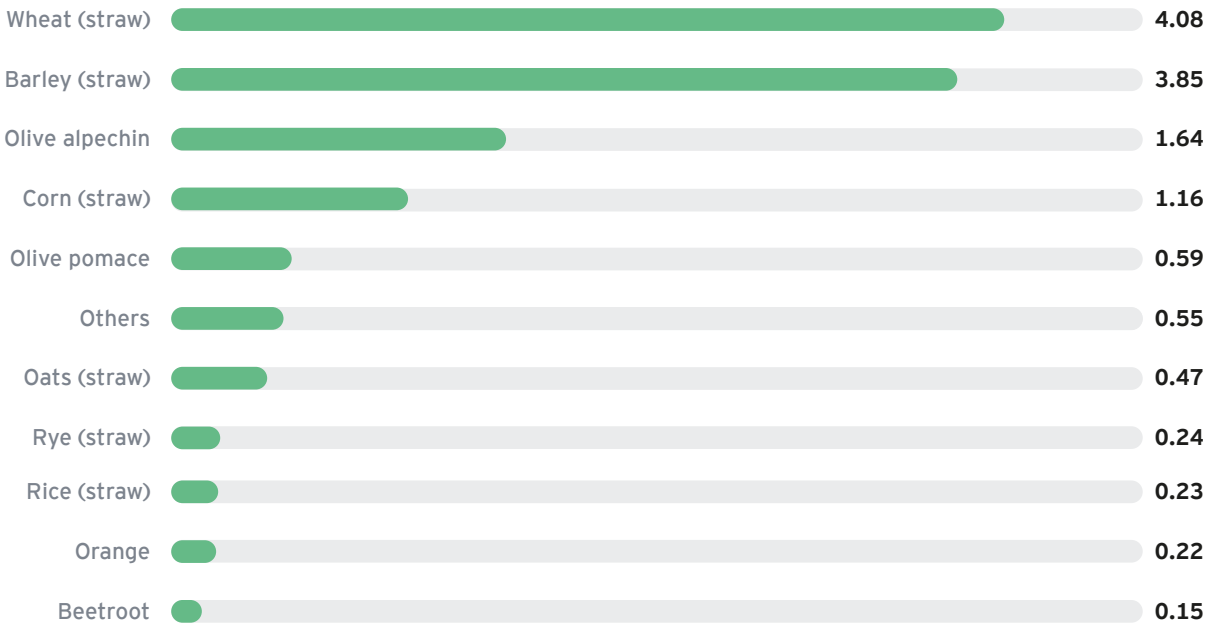
Source:
EY Parthenon.

This concentration poses a significant issue for available energy, as both types of waste are often utilized for higher-value purposes, reducing the availability of energy from plant sources by 76%. The potential to exceed this threshold will depend on the incentives provided to farmers by biomethane developers and the overall economics of biomethane. This includes the willingness of offtakers to pay and regulatory requirements for waste management, particularly regarding manure practices. Effective incentives could encourage farmers to engage with biomethane projects.

80%-17%

Among the main types of plant waste contributing to accessible biomethane energy, two types stand out: straw and other crop residues (80%) and olive pomace and similar waste (17%)

Figure 40 **Top 10 plant-origin available energy** (TWh)

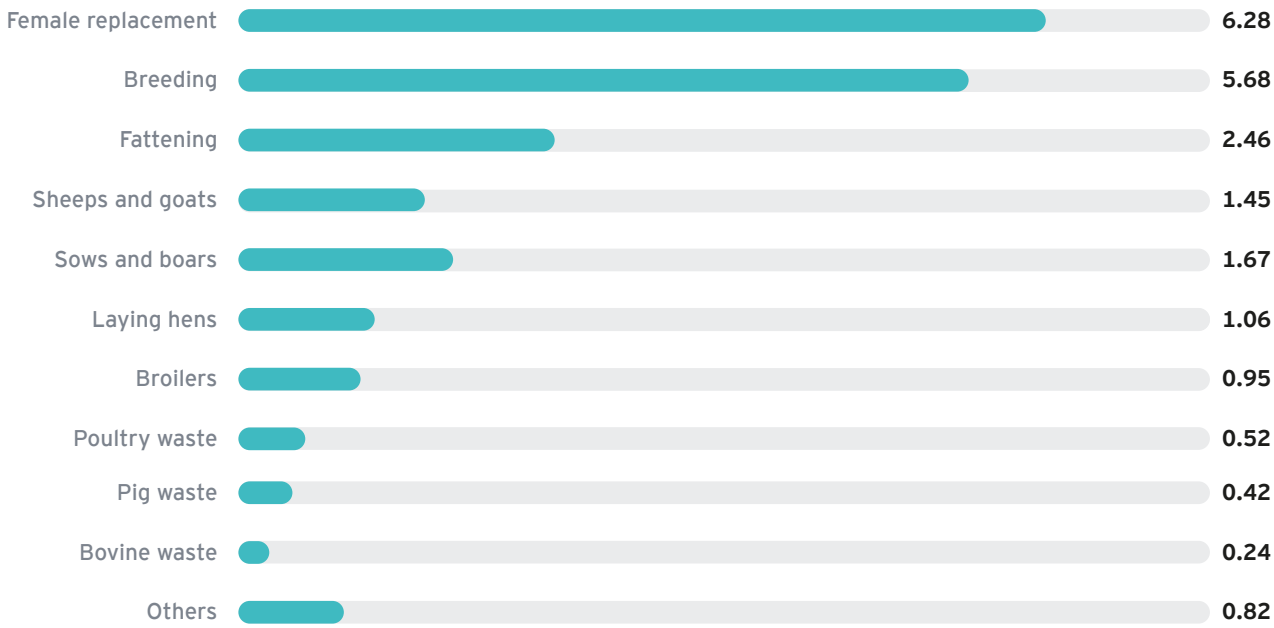


Source:
EY Parthenon.

For plant-origin energy, it is crucial to note the dependence of potential, accessible, and available energy on the annual harvest quality. The amount of waste that can be captured is directly correlated with the harvest yield each year.

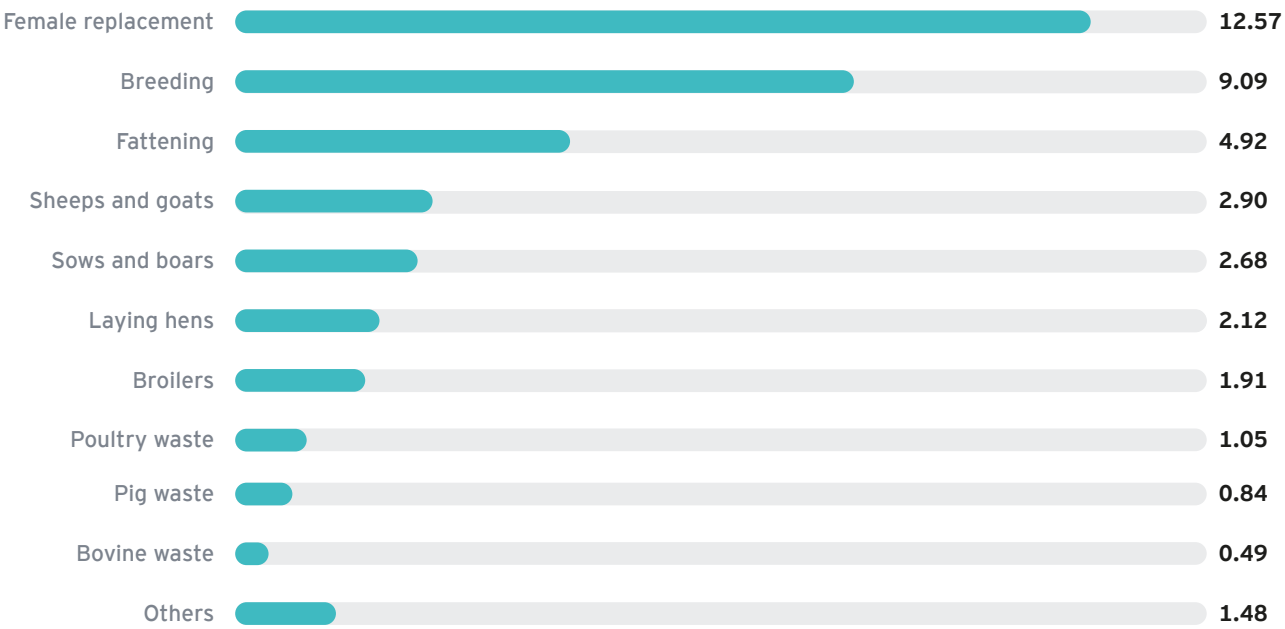
On the animal waste side, there is also a high concentration in the top 10 wastes, led by female breeding (31%), rearing (23%) and fattening (12%).

Figure 42 **Top 10 animal-origin available energy** (TWh)



Source:
EY Parthenon.

Figure 41 **Top 10 animal-origin accessible energy** (TWh)



Source:
EY Parthenon.

In terms of available energy, the distribution remains consistent but shows a 46% decrease compared to accessible energy. Although this is lower than the decrease observed for plant-origin energy, it is still significant due to the competition for some animal wastes, as previously mentioned.

Biomethane Efficiency and Carbon Footprint by Source

Plant-origin biomethane typically exhibits higher efficiency than animal-origin biomethane due to the composition and availability of raw materials. Energy crops such as maize, beet, and sorghum, which are rich in carbohydrates, cellulose, and hemicellulose, are effectively converted into biomethane through anaerobic digestion. In this process, microorganisms decompose organic matter without oxygen, generating biogas primarily composed of methane and carbon dioxide. Energy crops are chosen and grown for their high biomass yield and efficient breakdown, which maximizes methane production.

In contrast, animal-based biomethane comes mainly from residues such as manure and other organic waste. These materials have a lower energy content and methane potential compared to energy crops. Manure contains a higher proportion of non-fermentable materials and fewer carbohydrates available for anaerobic digestion, resulting in lower methane production per unit of raw material.

Additionally, the variability in manure composition can affect the efficiency of the anaerobic digestion process, whereas energy crops can be managed and controlled to optimize their yield. Consistency and optimization in plant cultivation contribute to a higher and more predictable yield in biomethane production compared to animal residues.

In summary, plant-origin biomethane is estimated to produce 1.99-2.98 MWh per ton of plant-based biomass, while animal-origin biomethane yields 0.20-0.79 MWh per ton of animal manure. The significant difference between plant and animal-origin biomethane, as well as the variability in animal-origin waste, is particularly noteworthy.

Regarding the carbon dioxide footprint, biomethane from plant-based sources generally has a higher carbon footprint compared to animal-based sources. This is due to several factors related to production processes and the nature of the raw materials. Growing crops for plant-based biomethane demands significant amounts of fertilizers, pesticides, and water, all of which contribute to carbon dioxide and other greenhouse gas emissions throughout their production, transportation, and application. Additionally, the use of agricultural machinery for planting, harvesting, and processing these crops further increases carbon dioxide emissions.

On the other hand, animal-based biomethane is primarily produced from organic waste such as manure and food industry by-products. These waste materials are already available and, if not utilized, would naturally decompose and release methane (a much more potent greenhouse gas than carbon dioxide) into the atmosphere. By capturing and using these waste materials to produce biomethane, methane emissions are avoided, resulting in a more favorable carbon balance. Moreover, animals generate waste regardless of its use for biomethane production, meaning that utilizing these wastes does not require additional carbon dioxide emissions associated with producing new resources, as is the case with plant cultivation.

According to a study that assessed four different plants in Italy with a higher or lower proportion or plant or animal-origin waste, it was shown that a 100% maize plant which produced 1000 kW had a carbon dioxide footprint of 56.11 grCO2eq/MJ while a plant mainly fed by animal-origin waste had a carbon dioxide footprint of -93.05grCO2eq/MJ, which validates the rationale stated above.

In summary, the higher carbon dioxide footprint of plant-based biomethane is mainly due to emissions from the production of raw materials and the use of agricultural machinery, whereas animal-based biomethane benefits from using existing waste, thereby reducing the overall environmental impact.

3.4. Conclusions

Biomethane is crucial for the EU's 2050 climate goals, offering a sustainable alternative to fossil fuels. It is especially valuable for heat generation in hard-to-abate industries like metallurgy, glass, and cement, where electrification alone is insufficient. Spain's extensive gas infrastructure and large agricultural sector provide a strong foundation for biomethane development. Moreover, biomethane helps reduce carbon dioxide emissions by repurposing waste, while also delivering economic and employment benefits. This study examines uncertainties related to feedstock availability and market demand. In 2023, Spain's natural gas demand was 325.4 TWh, while the PNIEC targets 20 TWh of biogas by 2030. This analysis quantifies Spain's biomethane potential, focusing on livestock, animal, and plant feedstock sources.

The study evaluates Spain's potential for biomethane production from livestock, animal, and plant waste, excluding forest biomass, landfills, FORSU, and WWTP due to accessibility constraints. It employs anaerobic digestion and gasification methods. Key metrics include Total Solids, Volatile Solids, and biogas potential. Waste is categorized into 26 primary categories and 124 subcategories. Accessibility and availability coefficients address legislative, practical, and alternative use limitations. Covering all 50 provinces as well as Ceuta and Melilla, the study aims to quantify Spain's biogas potential and pinpoint strategic production locations to optimize biomethane development.

The total potential energy from animal and plant sources is 104.92 TWh, with a relatively balanced contribution from both. However, the accessible energy drops to 95.91 TWh, largely due to a reduction in animal-origin sources. The available energy further decreases to 34.75 TWh, significantly impacted by high competition for plant-based materials, which affects their availability and economic viability for projects.

In summary, livestock waste contributes substantially to both accessible and available energy, though there is a notable reduction from potential to available energy due to legislative restrictions and logistical challenges. Plant-origin waste offers a higher level of accessible energy, but a significant portion is lost when considering available energy due to its high value in alternative markets, such as bio-plastics and fertilizers, as well as competition from food uses like olive waste. Regarding key locations, Lleida stands out in Spain with 5.29 TWh of accessible energy, followed by Huesca and Burgos known for their significant plant energy contributions. Badajoz ranks highly due to its balanced mix of animal and plant energy sources, supported by livestock farming and extensive agriculture. Provinces like Jaén and Valladolid exhibit similar balanced energy profiles comparable to Huesca and Burgos, emphasizing their substantial roles in Spain's biomethane potential landscape.

In terms of key waste sources, plant-based waste is primarily composed of withdrawals/straws (80%) and olive pomace/other waste (17%). However, available energy from these sources experiences a 76% reduction due to competition from alternative uses. For animal-based waste, the main contributors are female breeding (31%), rearing (23%), and fattening (12%). Although available energy from animal sources also declines, the reduction is less severe at 46%, attributable to lower competition compared to plant-based waste.

As final conclusions, it can be stated that:

1. Overall Potential

Spain has a significant potential to develop its biomethane industry, with accessible energy levels far surpassing the 2030 PNIEC and IDAE targets. There is enough feedstock to achieve the objectives.

2. Strategic Provinces

It will be critical to focus on provinces with high potential and a balanced mix of livestock and plant waste for optimal biomethane production.

3. Challenges

Addressing the competition for plant waste and improving the collection and utilization efficiency of livestock waste can help maximize available energy across the country.

4. Other considerations

Plant-based biomethane typically achieves higher efficiency due to energy crops' rich carbohydrate content, maximizing methane production through anaerobic digestion. In contrast, animal-based biomethane, sourced from lower-energy manure, varies in efficiency due to its composition and inconsistent digestibility. This variability affects methane yield. Regarding the carbon dioxide footprint, plant-based biomethane production generally has a higher carbon dioxide impact due to the use of fertilizers and machinery. In contrast, animal-based biomethane provides environmental benefits by repurposing existing waste and preventing methane emissions. Therefore, optimizing biomass selection and process efficiency is crucial for enhancing both biomethane output and sustainability. Additionally, it is expected that livestock-based biomethane may prove more profitable than plant-based options. This is because plant-based operators typically offer essential services to farmers, although this advantage is counterbalanced by higher logistics costs that must be factored into the overall evaluation.

3.5. References and Bibliography

Introduction and Context

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3.6. Appendix

Calculation Methodology

For the purposes of this study, chosen method for extracting energy from biogas is anaerobic digestion, a widely used technique for producing biogas from easily degradable feedstocks such as livestock waste, agri-food waste, and sewage sludge. In addition, gasification is an emerging technology being explored for converting more challenging, less degradable waste materials into energy.

Before looking at the methodology, it is important to define a few concepts:

- **% TS (Total Solids):** These consist of the amount of matter remaining as residue after drying or evaporation at 105ºC.
- **% VS (Volatile Solids):** Total solids subjected to combustion (at a temperature of approx. 550ºC) transform organic matter to CO_2 and H_2O. This weight loss is interpreted in terms of organic or volatile matter (SV).
- **Biogas potential:** The amount of biogas that can be extracted from the volatile solids contained in the feedstock substrates.
- **HHV (High Heating Value):** Total energy released when a substance is burned in an oxygenated atmosphere.

The procedure for the calculation of the existing energy in Spain was as follows:

Substrates
Raw Material Production x Direct Coef.

Biogas
Substrates x % TS x % VS x Biogas Pot.

Biogas
Biogas x % CH_4 X HHV

In order to calculate the amount of biogas generated, it is necessary to obtain the **amount of substrate**, i.e., existing usable raw material.

Livestock

$$Substrate\left(\frac{t}{year}\right) = No.\,of\ livestock\ (head) \times Coef.\,Directo\ \left(\frac{t}{head \times year}\right)$$

Animal

Land-based livestock

$$Substrate\left(\frac{t}{year}\right) = Slaughterhouse\ waste\ \left(\frac{t\ animal}{year}\right) \times Direct\ Coef.\left(\frac{t}{t\ animal}\right)$$

Fish

$$Substrate\left(\frac{t}{year}\right) = Producer\ residues\ \left(\frac{t\ waste}{year}\right) \times Direct\ Coef.\ \left(\frac{t}{t\ waste}\right)$$

Plant

$$Substrate\left(\frac{t}{year}\right) = Crop\ production\ \left(\frac{t\ produced}{year}\right) \times Direct\ Coef.\ \left(\frac{t\ withdrawn}{t\ produced}\right)^{1}$$

[1] $\frac{t\ withdrawn}{t\ produced}$ or $\frac{t\ non-compliant}{t\ produced}$ or $\frac{t\ non-compliant}{t\ produced}$ or % Qty processed or % Remaining prod.

Biogas generation is determined by:

$$Biogas\left(\frac{m^3}{year}\right) = Substrate\left(\frac{t}{año}\right) \times \%\,TS_{total\ solids} \times \%\,VS_{volatile\ solids/totals} \times Biogas\ \text{Potential}\ \left(\frac{kWh}{m^3}\right)$$

To determine the **energy generated from** the estimated **biogas**, it is necessary to know the methane content and the calorific value of the biogas, according to the formula:

$$Energy\left(\frac{kWh}{year}\right) = Biogas\left(\frac{m^3}{year}\right) \times \%\,CH_4 \times HHV_{High\ Heat\ Value}\left(\frac{kWh}{m^3}\right)$$

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