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ENERGY RESEARCH

From Iberia to France: Renewable Portfolio Optimisation Across Borders

2 July 2024

Madrid, Spain

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Source: Aurora Energy Research

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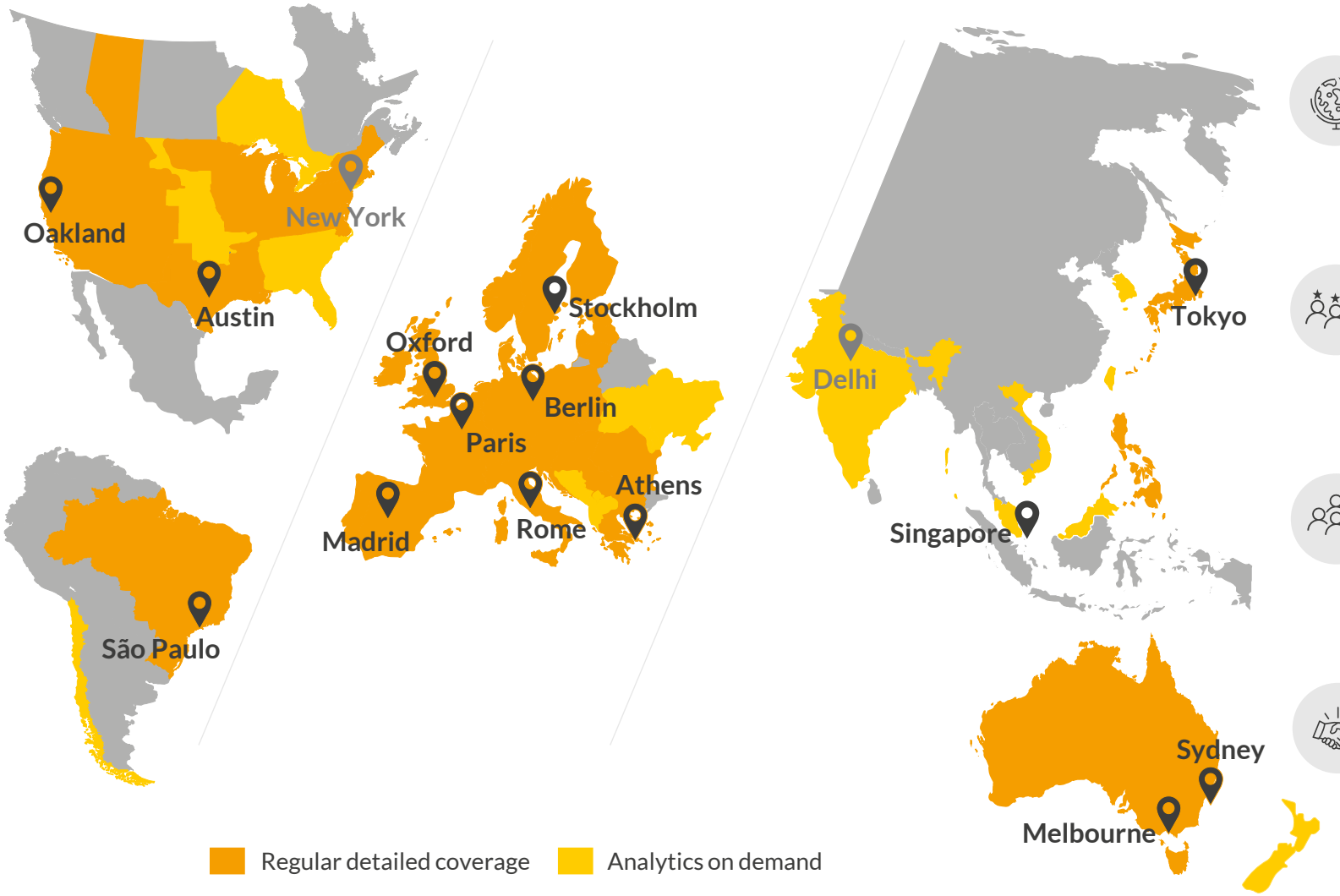

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Source: Aurora Energy Research

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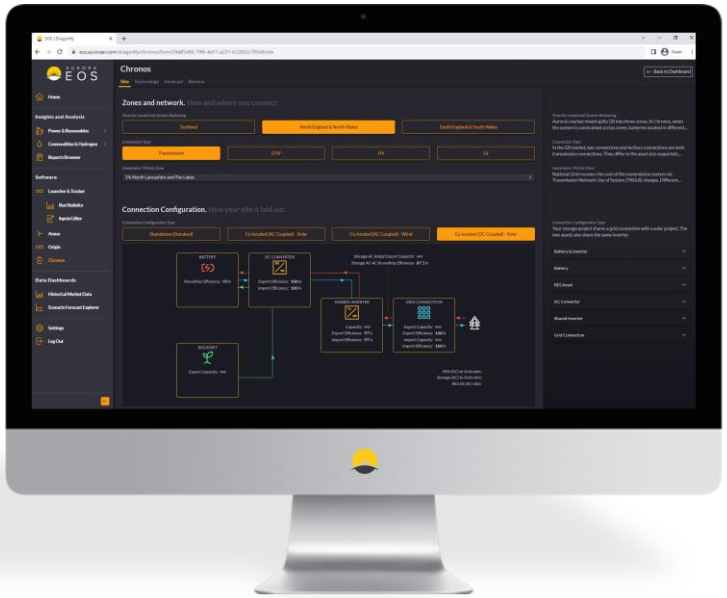

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- What are the main risks for renewables?

Portfolio diversification in Iberia

- What would be an optimal portfolio that maximises returns while mitigating risks?

Portfolio diversification in France and Spain

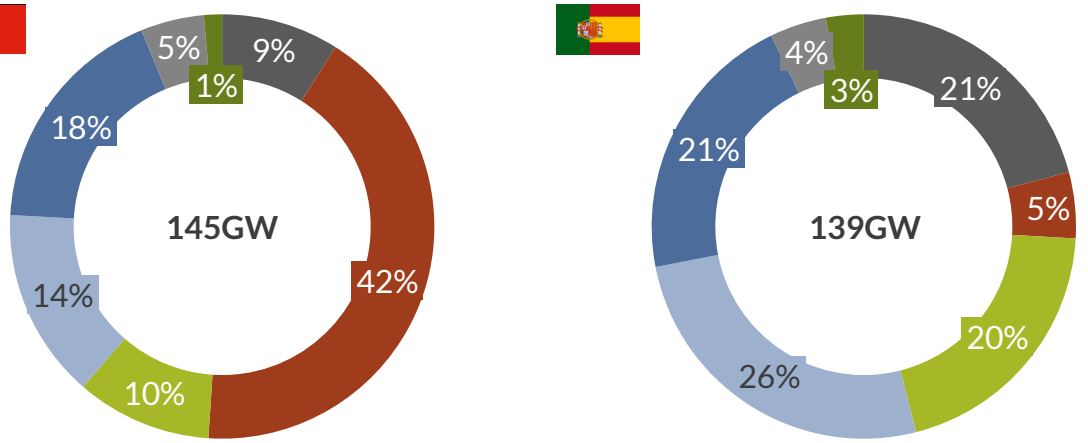
- What is the outlook for renewables in France?
- What would be an optimal cross-border portfolio that maximises returns while mitigating risks?

Key Takeaways

Iberia and France have different capacity and generation mixes; investors need to consider country specific dynamics when allocating capital

The capacity stack in Iberia[1] is dominated by renewables and CCGTs, while France is dominated by nuclear power, with a more modest presence of RES[2]

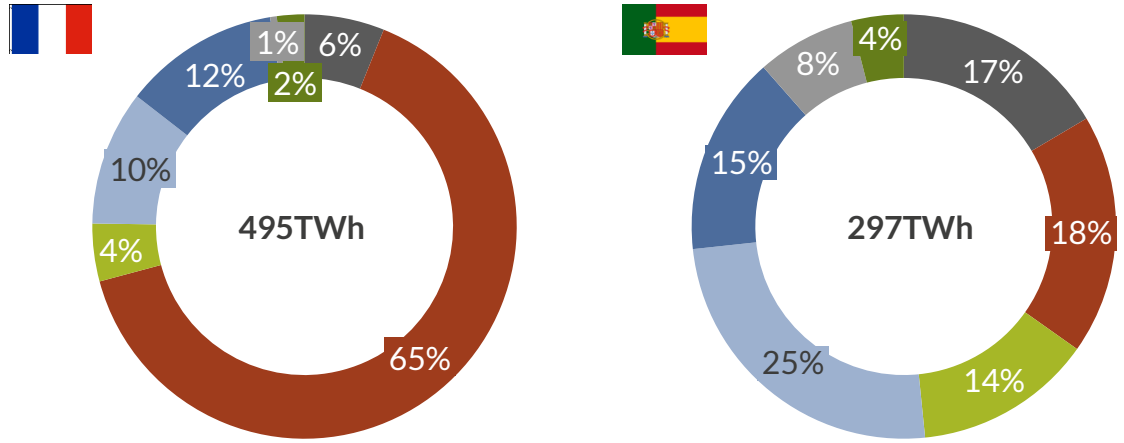
Installed capacity in December 2023, per country
GW, % of total GW



- Iberia has a lower nuclear capacity (5% of total), a higher CCGT capacity (21% of total) and a more important presence of intermittent renewables, accounting for 46% of its total capacity.
- France has a high nuclear capacity (42% of total), whereas it has a relatively low capacity of fossil-fuel powered plants (13% of total). Its intermittent renewable installed capacity is modest: 25% of total.

This is reflected in the generation mixes, which present significant differences between Iberia and France

2023 total power generation, breakdown by technology
TWh, % of total TWh



- Iberia[1] has a more balanced mix, with fossil fuels providing 24% of the total generation, nuclear providing a 18%, and intermittent renewables providing a 39% share out of the total generation.
- 93% of the French generation is carbon-free, and 7% is linked to fossil fuel. Of its total generation, roughly two thirds corresponds to nuclear power, and 15% of its total generation corresponds to intermittent renewables.
- The price-setting dynamics in both countries are different; exposure to both might help investors to obtain complementary revenue streams.

CCGT | Nuclear | Solar PV[3] | Wind[4] | Hydro[5] | Other thermal[6] | Other RES[7]

1) Iberia refers to the aggregated data of both Spain and Portugal, excluding islands. 2) Renewable Energy Sources. 3) Excludes behind-the-meter PV. 4) Includes on-shore wind, and if applicable, off-shore wind. 5) Hydro includes run-of-river, reservoir, and pumped hydro. 6) Other thermal includes cogeneration, coal, oil, and non-renewable waste. 7) Other RES includes solar CSP, biomass, and renewable waste, and "other" (RtE). "Waste" (RtE) is assumed to be 50% other thermal and 50% other RES.
Sources: Aurora Energy Research, REE, RTE

Renewable generation in Iberia represents 59% of the current generation mix; we expect it to increase to 84% by 2030, increasing price cannibalisation risks.

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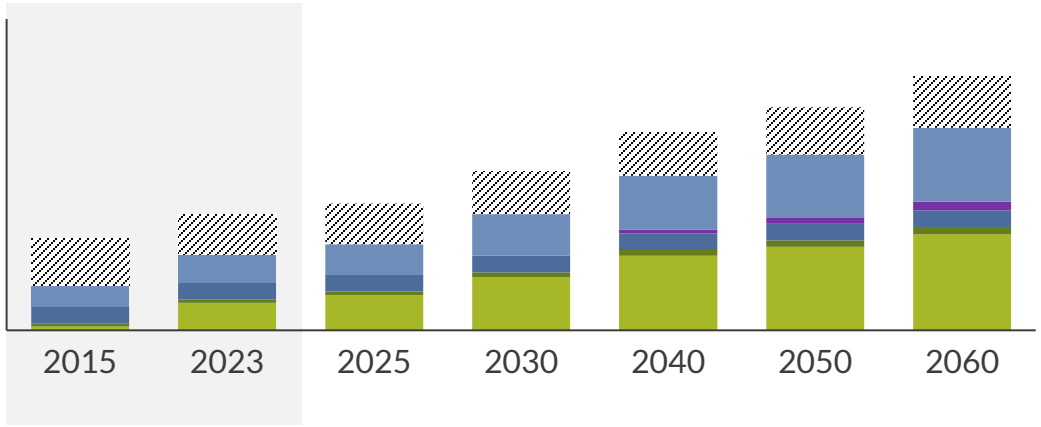
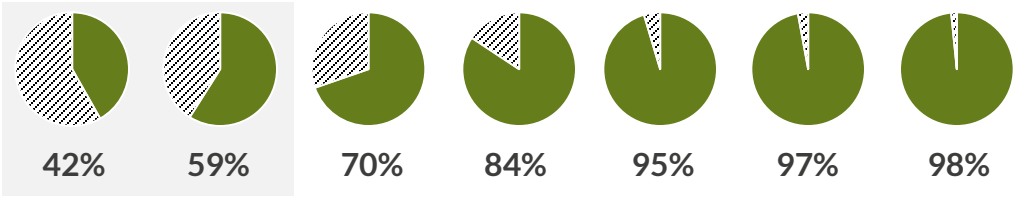
Installed capacity, GW



Share of RES capacity in generation[1], %

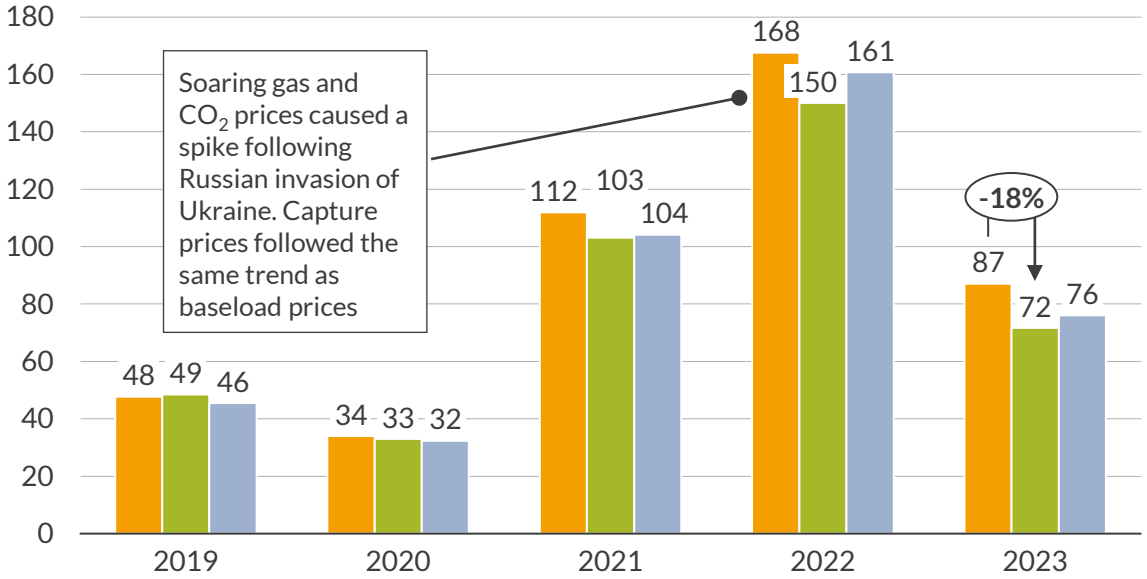


- RES capacity has significantly increased since 2015, with 41GW added in 2015-2023. Solar is the technology with highest new additions in this period.
- A drive towards decarbonisation sees renewable capacity increasing significantly in Iberia – total installed capacity of wind and solar increases by more than 200% in Iberia from 2024 to 2060.

Solar[2] | Other RES[3] | Hydro | Offshore wind | Onshore wind | Other[4]

Baseload and renewables capture prices

€/MWh (nominal)



Discount to baseload

%

2019	2020	2021	2022	2023
-2%	3%	8%	12%	19%
4%	5%	7%	5%	12%

- Renewables capture prices are steadily decoupling from baseload, with increasing cannibalisation.

Baseload | Solar | Onshore wind

1) Calculated over national generation, i.e. excluding imports/exports and storage losses. 2) Includes behind-the-meter solar PV. 3) Other renewables includes biomass, hydro run-of-river, tidal, and solar CSP. 4) Other includes all non-renewable technologies such as: nuclear, coal, gas CCGT, hydrogen CCGT, gas/oil peaker, hydrogen peaker, interconnectors, battery storage, and pumped storage.

Source: Aurora Energy Research, REE, REN

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- What is the outlook for renewables in France?

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- How can portfolio diversification help to mitigate key risks?
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Portfolio diversification in Iberia

- What would be an optimal portfolio that maximises returns while mitigating risks?

Portfolio diversification in France and Spain

- What is the outlook for renewables in France?
- What would be an optimal cross-border portfolio that maximises returns while mitigating risks?

Key Takeaways

A diversified portfolio can help mitigate technology or country specific risk; however, systemic risk cannot be eliminated

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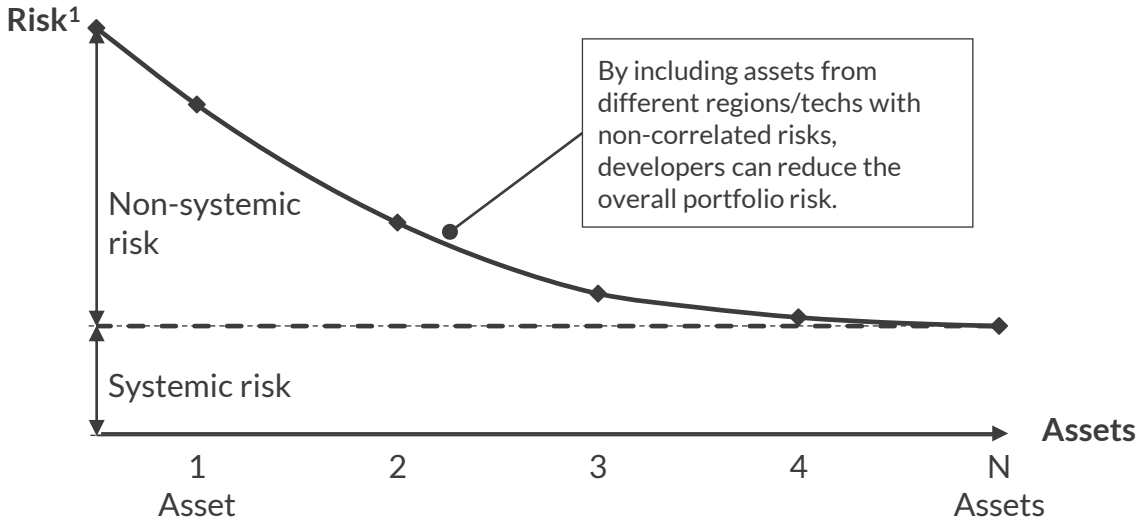
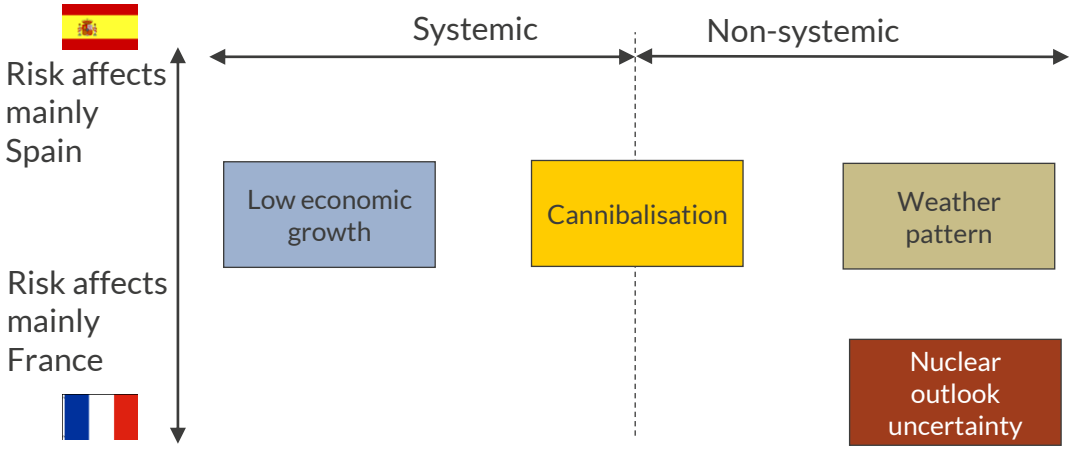
Risks can be classified into systemic and non-systemic risks; non-systemic risks can be mitigated by diversification



Risk in the context of portfolio management is associated with volatility and the potential for financial loss. It can be divided into:

1. **Systemic risk** refers to factors that impact global markets uniformly, such as economic downturns or global energy price fluctuations. These risks cannot be eliminated through diversification.
2. **Non-systemic risk** refers to factors that impact specific industries, or regions, such as policy decisions, competitive pressures, or local regulatory changes. These risks can be mitigated through diversification, as they do not affect the entire market uniformly.

We have identified four main risks for Spain and France, systemic risks are correlated in both countries while non-systemic risks are less correlated



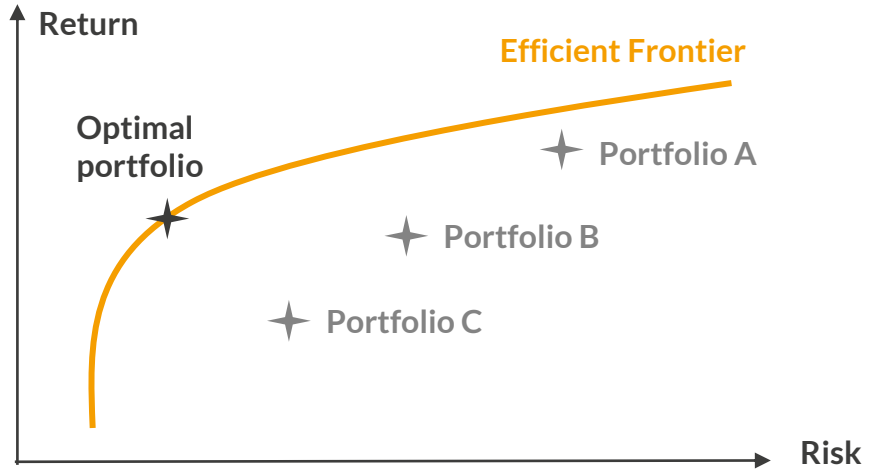
- We have identified four main risks: low demand growth, price cannibalisation, weather volatility, and nuclear outlook uncertainty.
- Weather patterns affect both countries, but it is not systemic as weather patterns can be uncorrelated.
- Low economic growth is likely to be correlated in both countries, as it assumes a world with slower GDP growth, low demand and low commodity prices.
- Nuclear outlook uncertainty mainly affects France.
- Cannibalisation is more relevant in Spain in the short term, while it might be more relevant in France for the long term.

1) The risk is shown for illustrative purposes, it does not reflect the real results of any existing portfolio.

Source: Aurora Energy Research

In our analysis we define a methodology that focuses on the downside risks applicable to renewables in Iberia

Portfolio theory suggests that it is possible to design an ideal portfolio which maximises investors' returns for any given level of preferred risks.



- The Efficient Frontier is the curve formed by the combinations that optimise returns for a given level of risk.
- The key benefits of portfolio diversification are:
  - ✓ Minimises the downside risk (in frequency and magnitude) of a portfolio.
  - ✓ More opportunities for higher returns with the same level of risk.
  - ✓ Helps reduce volatility of yearly returns.
  - ✓ Lowers financial costs and reduces the tax burden by allowing more debt (capital structure).
  - ✓ Similarly, decreases reliance on costly external funds for investments.

We assume that a fund allocates a budget for investing in 2025 in renewable projects; our portfolios combine two different locations and technologies.

1	**Location**	Diversifying within two different regions[1]
2	**Technology**	Diversifying two different renewable technologies[2] ▪ Wind: COD[3] in 2027, lifetime of 27 years. ▪ Solar: COD[3] in 2026 and a lifetime of 30 years.
3	**Location & Technology**	Diversifying two different renewable technologies (solar, wind) within two different regions.

Risk definition

The **risk** is defined as the downside risk of the portfolio, defined as follows:

1. We run the portfolio against a series of scenarios, which reflect risks.
2. Considering the relevant CAPEX and OPEX, we compute the IRR of the portfolio for each scenario and calculate the delta to a MAR[4], which we define as the portfolio IRR in our Central scenario.
3. We discard the positive values (upside risk) and compute the downside deviation, defined as:

$$Downside\ deviation = \sqrt{\frac{\sum_1^N negative\ IRR\ delta\ to\ Central_i^2}{total\ number\ of\ scenarios}}$$

1) The funds are split in 20% steps and allocated between the two countries (100%/0%, 80%/20%, 40%/60%, …, 0%/100%). 2) For each region/country, the funds are split in 20% steps for the two technologies, onshore wind and solar (100% wind/0% solar, 80% wind/20% solar, 60%/40%, …, 0%/100%). 3) Commercial Operations Date. This reflects that the investment is done in 2025; then the construction time is 2 years for onshore wind and 1 year for solar PV. 4) Minimum Acceptable Return.

Source: Aurora Energy Research

We have built a set of 17 scenarios that capture the key risks identified in the French and Iberian markets for a given set of portfolios

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We have run the portfolios analysed against our Central case and around this set of scenarios, in order to calculate the expected returns for each portfolio, as well as to quantify their associated risks.

Risk		Scenario	Description	Risk location
Cannibalisation	1-3	Achievement of government targets	▪ Iberia: capacities and interconnection capacity aligned with Iberia Government targets for 2030	
			▪ France: renewables and electrolyser targets as set out in the pluriannual plan for energy for 2028 reached	
			▪ Both Iberia and France meet their respective targets	
Low economic growth	4	Low scenario	▪ Aurora PRMF Low scenario (lower demand, and reduced commodity prices) with lower CAPEX	
	5	Low flexibility	▪ EV flexible demand reduced by 30% in France and Iberia ▪ Flexible electrolyser capacity reduced by 50% in both countries	
	6	Reduced demand in Iberia	▪ Reduction of demand by 3% in 2024, 5% in 2030 and 15% from 2050 onwards	
Nuclear outlook uncertainty	7	Nuclear life extension	▪ Lifespan extension to 60 years across all French nuclear fleet	
Weather pattern	8-17	Weather years	▪ Central scenario evaluated with 10 different weather years	

Source: Aurora Energy Research

1–3 Reaching Government Targets poses a downside risk, leading to a significant short-term delta in prices despite more flexibility in the system

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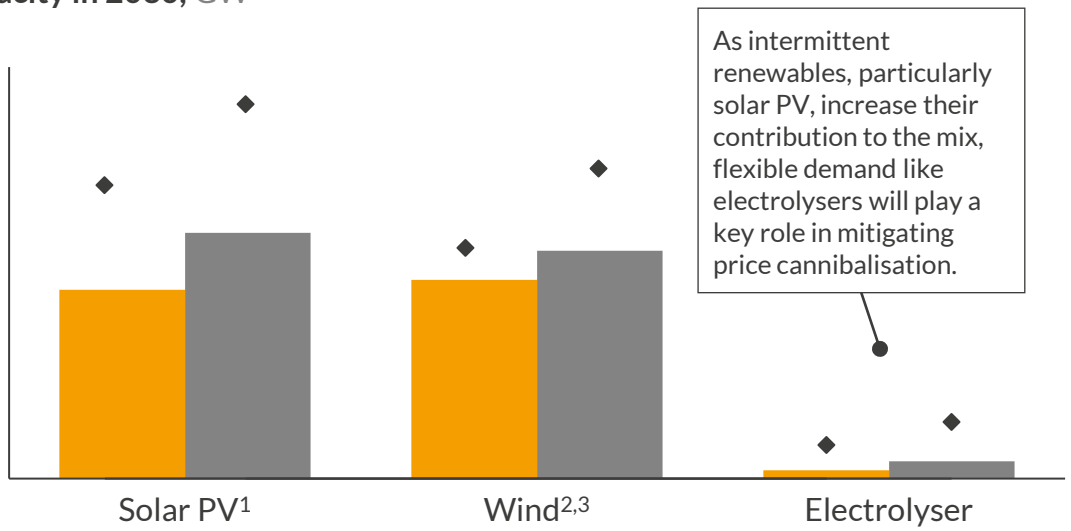
Spanish and French governments have set forth ambitious goals of renewable and electrolyser installed capacity in 2030.

Capacity in 2030, GW



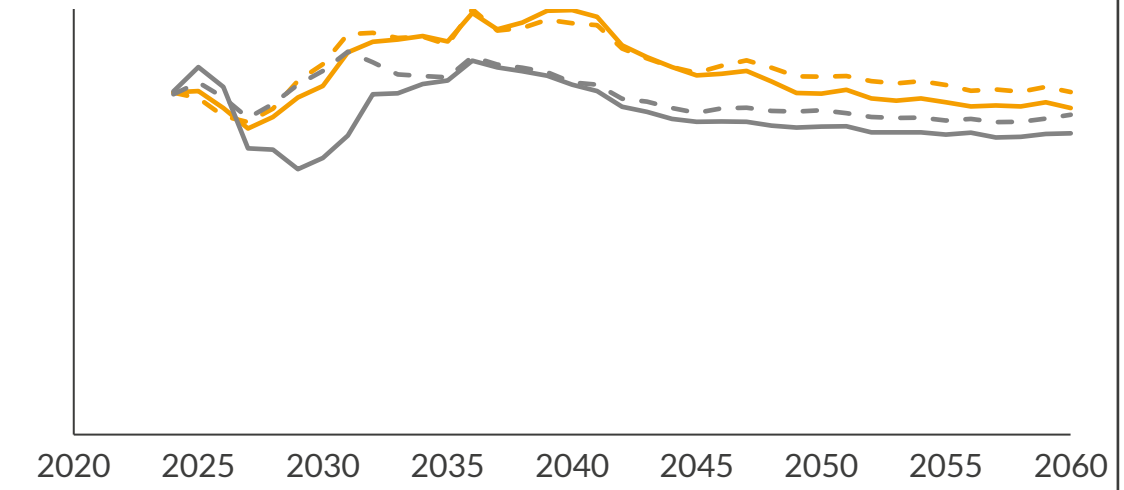
- Despite a combined aggressive annual buildout for both countries in our Central scenario, both regions still fall short of meeting government targets for 2030[4].
- Flexible demand rises with electrolyser capacity, increasing to 18GW (Government targets), combined for both Spain and France.

France - Aurora Central Spain - Aurora Central Government targets

Impact on Baseload prices

Baseload prices in Aurora Central and Government targets scenarios[5]

€/MWh (real 2023)



- While prices after the 40s follow a similar pattern, Spain is the most affected in the 2020s due to high renewables buildout and low interconnectivity.
- Prices in 2030 are lower than Central by 24% in Spain and 6% in France, highlighting the higher risk in Spain in the short term.
- Prices stabilise in the mid-30s and remain, on average, 4% lower for the rest of the timeline in both regions.

Aurora Central - France Aurora Central - Spain
Gov. targets - France Gov. targets - Spain

1) Includes solar behind-the-meter. 2) Include both onshore and offshore wind capacities. 3) Offshore wind capacities were adjusted to meet 2050 targets (45 GW) for FRA. 4) Government targets: For Spain, we refer to the updated draft PNIEC, published in 2023; for France, we refer to the PP3 targets for 2028. 5) Data shows prices under France and Spain Government targets scenarios, i.e scenario 3.

Sources: Aurora Energy Research, French NECP, Spanish NECP

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Portfolio diversification in France and Spain

- What is the outlook for renewables in France?
- What would be an optimal cross-border portfolio that maximises returns while mitigating risks?

Key Takeaways

We analysed 156 portfolios in Iberia against the 17 different scenarios which represent risk for assets located in Iberia

For the Iberian assets, we carried out an analysis which considers all the 17 scenarios described, reflecting portfolio's robustness against the risks mentioned before: cannibalisation, low economic growth, weather variation, and nuclear extensions in France

Scenario		Risk location	IBE
Achievement of government targets	1-3		X
			X
			X
Low scenario	4		X
Low flexibility	5		X
Reduced demand in Spain	6		X
Nuclear life extension	7		X
Weather years	8		X

Illustrative example

$$Downside\ deviation = \sqrt{\frac{\sum_1^N negative\ IRR\ delta\ to\ Central_i^2}{total\ number\ of\ scenarios}}$$

Central portfolio IRR[1] = 9.0% = MAR

Scenario	IRR	Delta to MAR	(Negative Delta)^2
1	7.5%	-1.5	2.25
2	9.2%	0.2	0
3	8.0%	-1.0	1.00
4	6.0%	-3.0	9.00
5	8.4%	-0.6	0.36
6	8.2%	-0.8	0.64
7	8.5%	-0.5	0.25
8[2]	N/A	-1.2	1.44
Total			**14.94**

$$Downside\ deviation = \sqrt{\frac{15.73}{8}} = 1.37\%$$

1) Does not represent any real portfolio, it aims solely at illustrating the methodology. 2) For the weather years, we directly calculate the downside risk of all of them together, and use this value as the negative delta to the MAR.

Source: Aurora Energy Research

We selected locations in Iberia for both wind and solar assets; wind assets present lower returns for higher risk in Iberia

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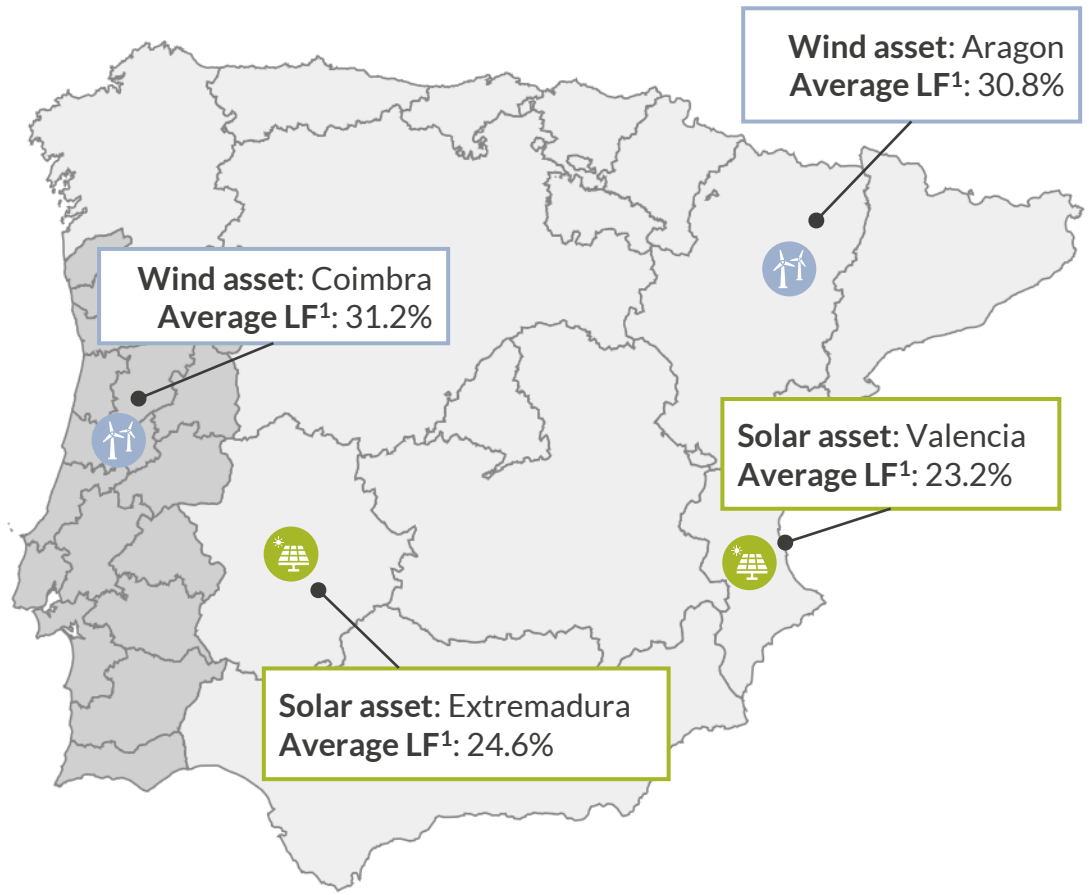
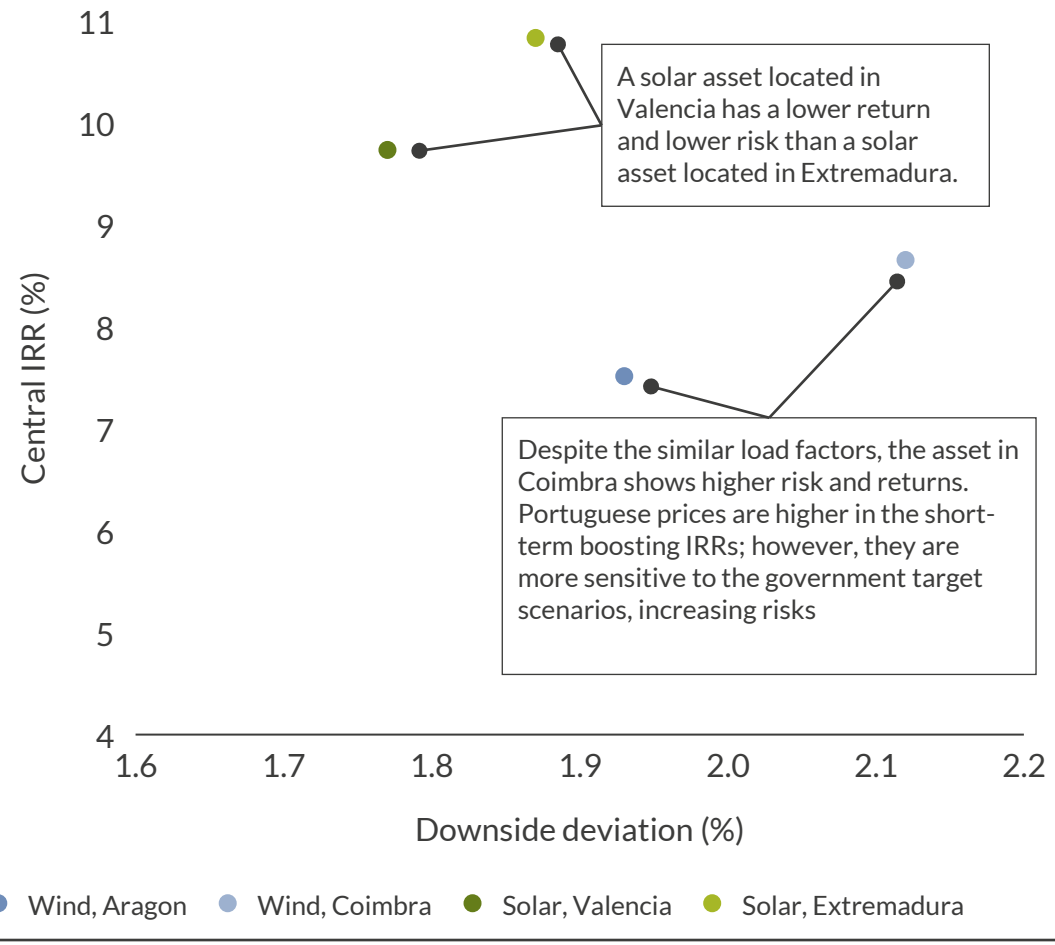
Sites selected



Returns and risk for single assets



1) Load Factor. 2) Average capture price for the asset in 2024-2060, expressed in €/MWh (real 2023).

Source: Aurora Energy Research

When considering all risks, solar portfolios yield the largest returns with a lower level of risk

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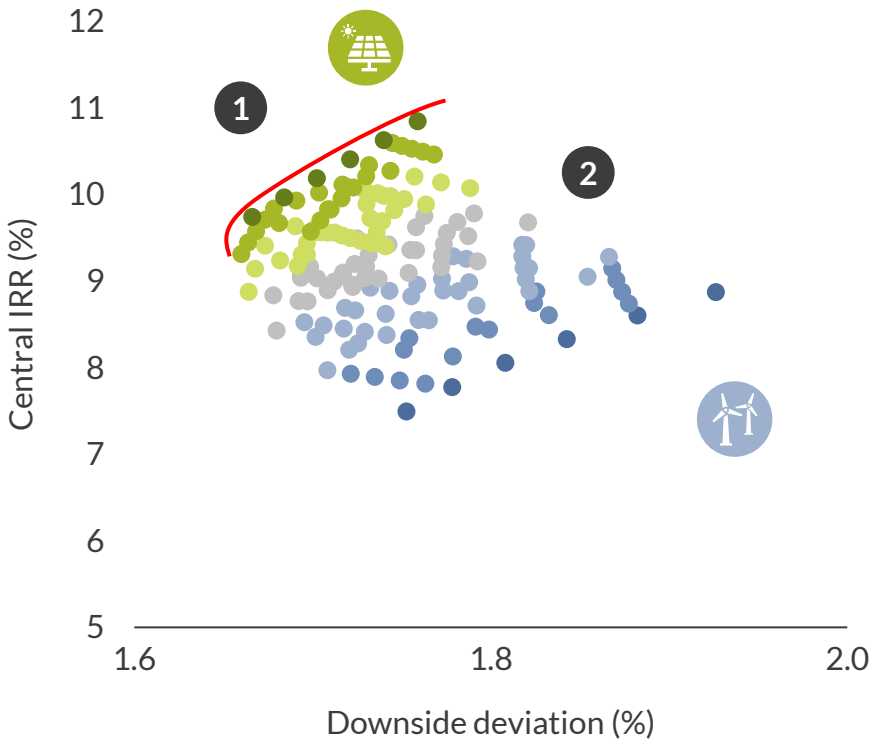
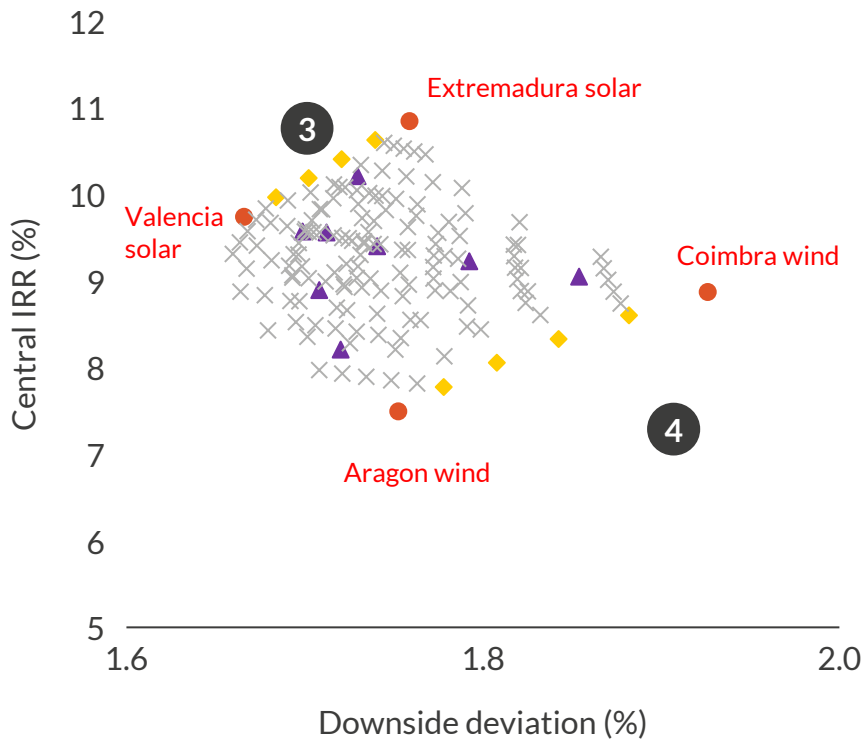
Scenario mix - IBE 2

We model 156 portfolios in Iberia located in Spain and Portugal composed of wind and/or solar assets with a deployment of capital in 2025[1]. We assess the profitability of each portfolio against the downside risk of all our scenarios.

Solar assets offer improved risk-return profiles compared to wind assets when all risks are considered



For solar assets, the region with higher returns also has higher risk, diversifying by region helps to mitigate risk



Share of wind asset in the portfolio (%) :
- 100%
-]80% ; 100%[
-]60% ; 80%]
-]40% ; 60%]
-]20% ;40%]
-]0% ; 20%]
- 0%
- Efficient Frontier

Type of diversification within the portfolio :
- 1 region, 1 technology
- 1 region, 2 technologies
- 2 regions, 1 technology
- 2 regions, 2 technologies

1) As mentioned on slide 11, considering 1 year construction time for solar and 2 years for wind, this is equivalent to say that the solar projects have COD 2026, and the wind projects have COD 2027.

Source: Aurora Energy Research

1. When looking at all scenarios, solar assets yield higher returns than wind assets, while having a lower risk level.
2. Adding solar assets to a wind portfolio in Portugal leads to a lower risk.
3. Solar assets, although still influenced by location, experience less variability in their production profile compared to wind assets. This results in a more stable risk profile for solar portfolios.
4. Wind assets present lower returns and higher risks than solar. The low correlation of wind profiles between the two countries leads to a high range of risk.

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Key Takeaways

Spain has a higher share of renewable generation than France, but not necessarily higher cannibalisation due to greater flexible demand

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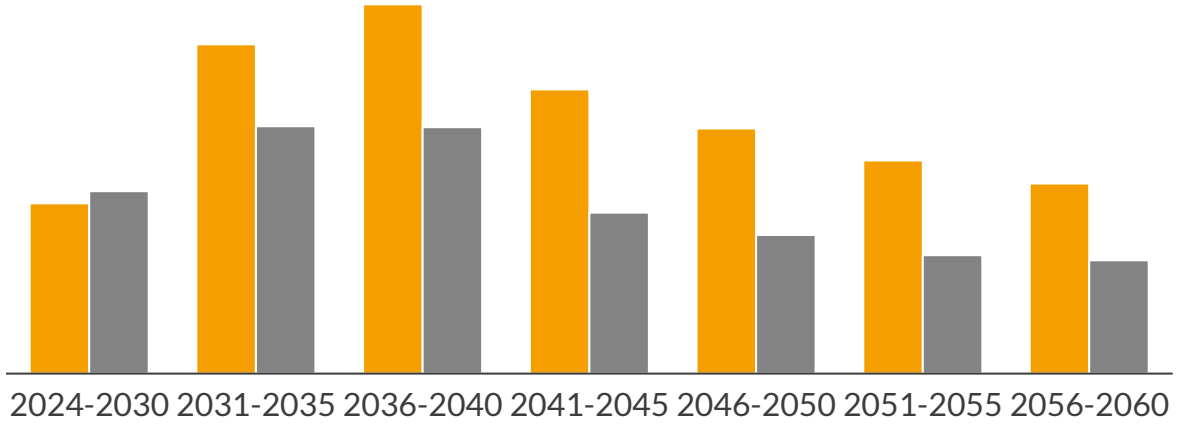
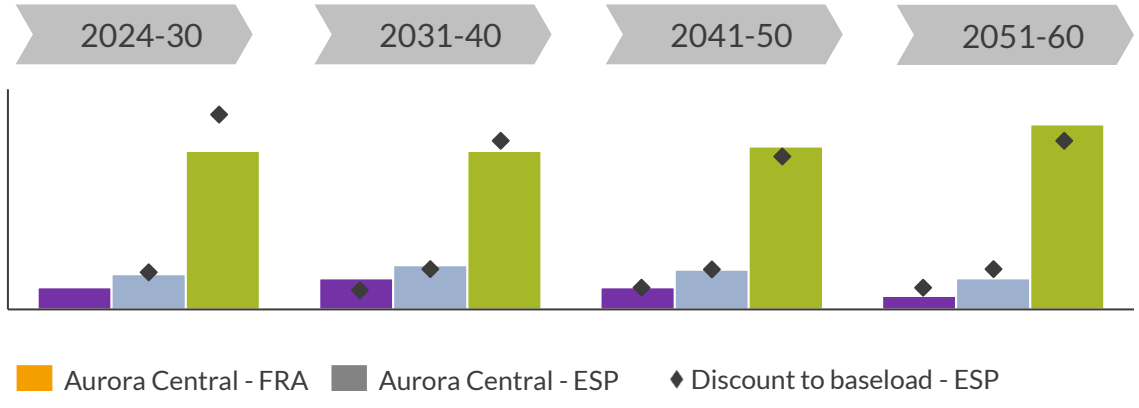
While baseload prices in Spain are expected to be higher than those in France in the short term, we expect them to be lower in the medium to long term

Baseload prices, €/MWh (real 2023)

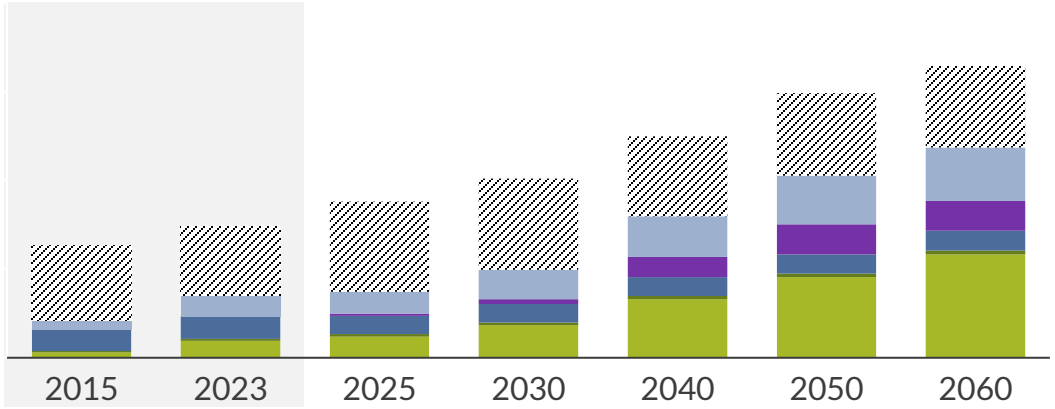


Average capture price to baseload price discount (France), %



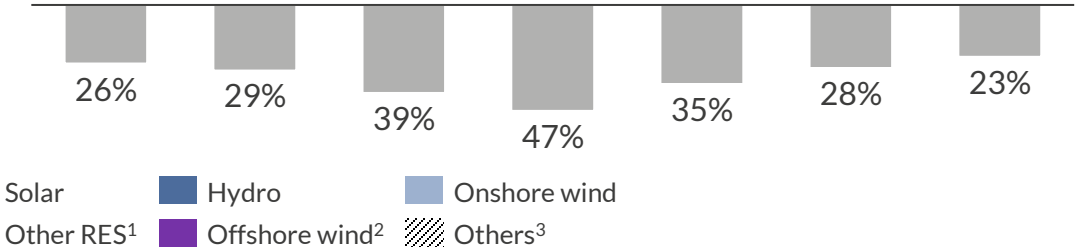
High nuclear and slower RES deployment in France lead to low RES share in the short-term; as nuclear phases out, the difference with Iberia narrows

Installed capacity in France, GW



Renewable share of total generation in France, %

Delta to Iberian renewable share of generation, pp.



1) Other renewables includes biomass, hydro run-of-river and tidal. 2) Offshore wind includes fixed and floating offshore wind. 3) Others includes nuclear, coal, gas CCGT, hydrogen CCGT, pumped storage, gas/oil peaker, hydrogen peaker, interconnectors, and battery storage.

Source: Aurora Energy Research

We analyse 156 portfolios in France and Spain, against all 17 scenarios which present risk to French and Spanish assets

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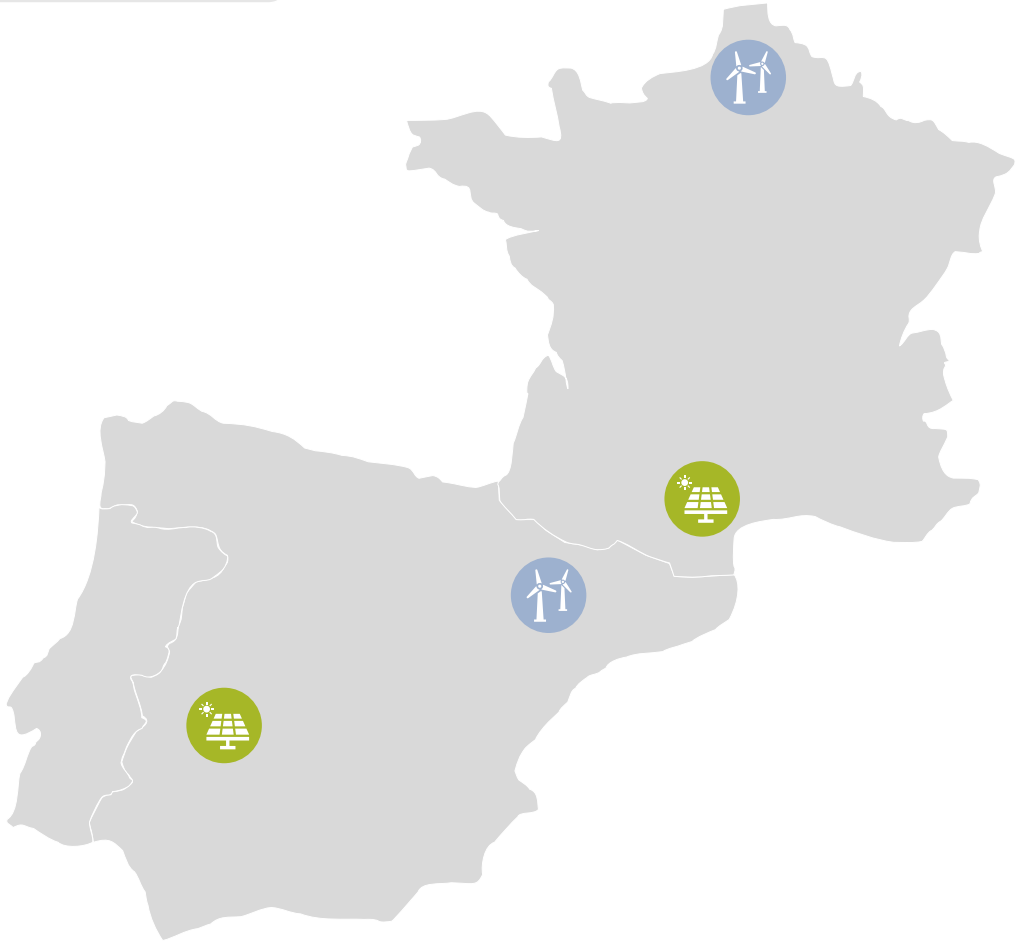
Our portfolios combine different locations (France/Spain) and technologies (wind/solar) for an investment in 2025.

1. **Location** — We model portfolios located either in France, or in Spain, or in both[1]
2. **Technology** — Diversifying two different renewable technologies[2]
   - Wind : 2-year construction time, COD[3] in 2027 and a lifetime of 27 years
   - Solar : 1-year construction time, COD in 2026 and a lifetime of 30 years
3. **Location & Technology** — Diversifying two different renewable technologies (solar, wind) within two different countries (France and Spain)

Location	Technology	Average load factor (%)
	Wind onshore	36.2%
	Solar	16.3%
	Wind onshore	30.8%
	Solar	24.6%

Sites selected



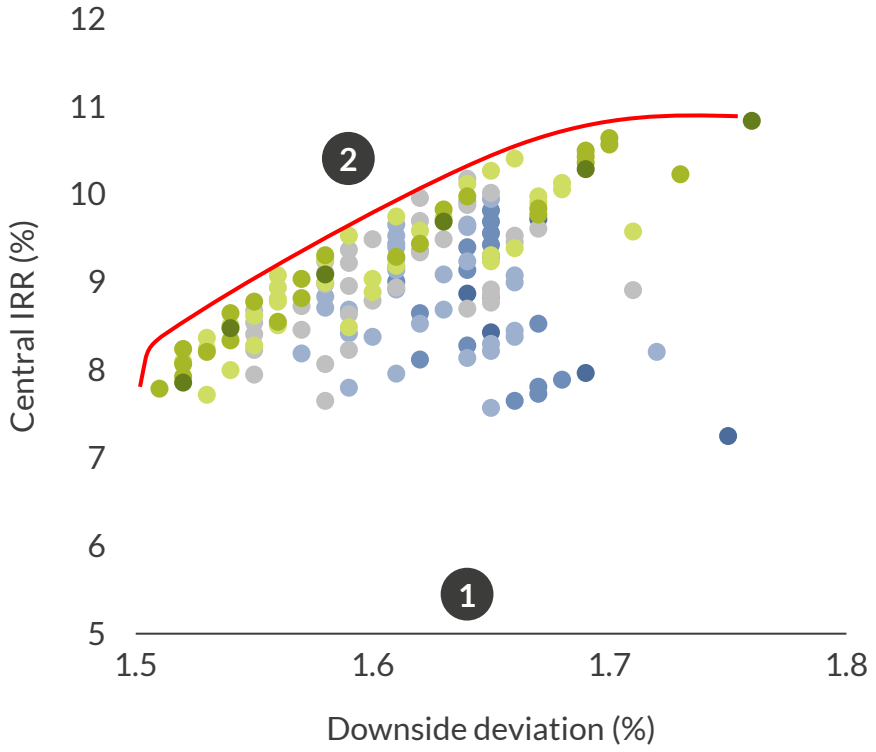
1) The funds are split in 20% steps and allocated between the two countries (100%/0%, 80%/20%, 40%/60%, ..., 0%/100%). 2) For each country, the funds are split in 20% steps for the two technologies, onshore wind and solar (100% wind/0% solar, 80% wind/20% solar, 60%/40%, ..., 0%/100%). 3) Commercial Operations Date. 4) Average capture price from 2024 to 2060 in Central scenarios.

Source: Aurora Energy Research

Diversifying a portfolio between the French and Spanish markets results in a more technologically diverse Efficient Frontier

We model 156 portfolios located in France and/or Spain and composed of wind and/or solar assets with a deployment of capital in 2025[1]. We assess the profitability of each portfolio against the downside risk of all our scenarios.

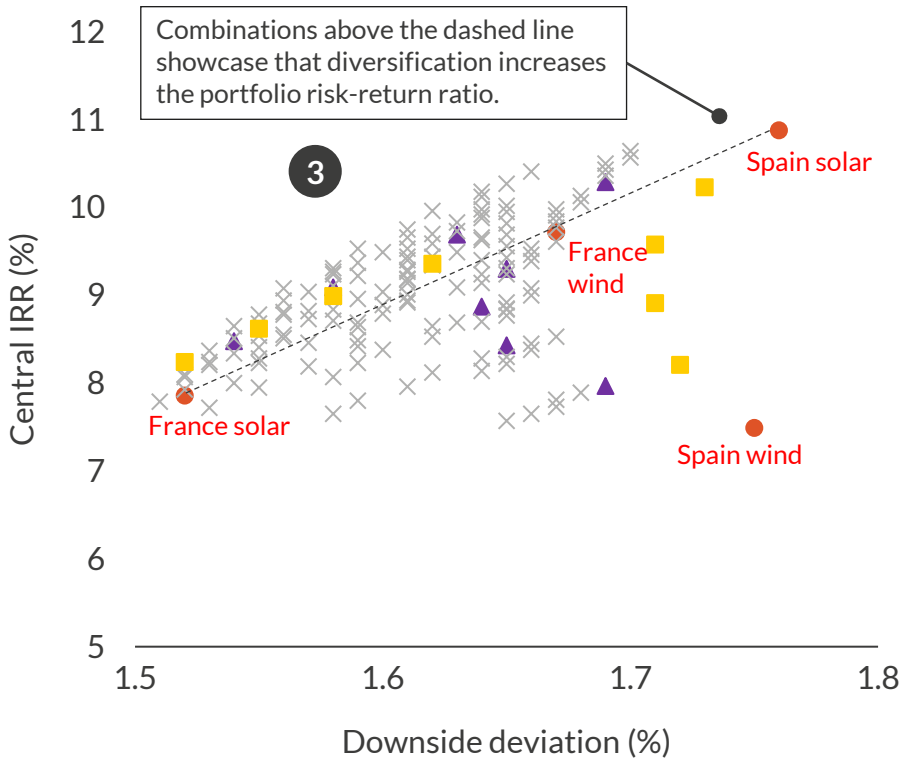
Unlike in the Iberia only case, portfolio performance is not clearly differentiated by the technology weight



Share of wind asset in the portfolio (%) :

- 100%
-]80% ; 100%[
-]60% ; 80%]
-]40% ; 60%]
-]20% ;40%]
-]0% ; 20%]
- 0%
- Efficient Frontier

The Efficient Frontier is composed of portfolios that diversify in both region and technology



Type of diversification within the portfolio :

- 1 country, 1 technology
- 2 countries, 1 technology
- 2 countries, 2 technologies
- 1 country, 2 technologies

1) As mentioned on slide 11, considering 1 year construction time for solar and 2 years for wind, this is equivalent to say that the solar projects have COD 2026, and the wind projects have COD 2027.

Source: Aurora Energy Research

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Scenario mix – all scenarios

1. Cross-border diversification mitigates non-systemic risks by exposing assets to different baseload prices. Consequently, the overall risk levels are lower than in the single-country case.
2. The Efficient Frontier is composed of portfolios comprising a mix of wind and solar assets, with the optimal portfolio's being composed of mainly solar.
3. Optimal cross-border portfolio combinations are diversified both in terms of technology and country. A combination of solar assets located in France and Spain, combined with wind assets located in France represent the majority of optimal portfolios on the Efficient Frontier.

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Introduction

- What are the key market dynamics in Spain and in France?
- What is the outlook for renewables in France?

Risks and opportunities for renewables

- How can portfolio diversification help to mitigate key risks?
- What are the main risks for renewables?

Portfolio diversification in Iberia

- How are regional wind and/or solar patterns correlated?
- What would be an optimal portfolio that maximises returns while mitigating risks?

Portfolio diversification in France and Spain

- What is the outlook for renewables in France?
- What would be an optimal cross-border portfolio that maximises returns while mitigating risks?

Key Takeaways

Key takeaways

1. Historically, Iberian renewable assets, particularly solar PV, have experienced increased price cannibalisation. Our Central scenario forecasts a significant increase in renewable production in the future (renewable generation in the energy mix is expected to more than double between 2023 and 2040) which will exacerbate these risks.

2. We have identified four key systemic and non-systemic risks that affect Iberia and France; price cannibalisation, low economic growth, nuclear outlook uncertainty (i.e., extension of nuclear power plant lifetimes), and weather pattern variations. Technological (solar, wind) and locational (across regions or countries) diversification can be a solution to mitigate non-systemic risks, as these risks will not affect different assets and regions equally.

3. Considering all the identified scenarios in Iberia, solar assets achieve higher IRRs than wind assets due to lower CAPEX and relatively high load factor in Iberia. In terms of risks, locational and technological diversification makes a difference, as it can reduce the risk level for the same IRR or increase the IRR for the same risk level. This is amplified with cross border diversification, which decreases the overall risk levels of the portfolio due to exposure to different baseload prices, and yearly weather patterns, as well as to differences in load factors.

4. A portfolio's exposure to non-systemic risks, such as variations in weather patterns, will depend on individual countries and risk can be mitigated by technological diversification. Additional diversification across countries lowers risk exposure for all portfolios against all downside scenarios.

Source: Aurora Energy Research

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