



Ministère de l'Industrie
Agence Nationale pour
la Maîtrise de l'Energie



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TUNISIA: Derisking Renewable Energy Investment

Selecting Public Instruments to Promote Renewable
Energy Investment for the Tunisian Solar Plan NAMA

Sensitivity Analyses



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This publication builds on a series of prior research papers. This includes the original *Derisking Renewable Energy Investment* (Waissbein *et al.*, 2013) report, which sets out the methodology used in this publication, as well as *Transforming On-Grid Renewable Energy Markets*, (Glemarec *et al.*, 2012), which synthesises UNDP's experiences with renewable energy markets.

This report should be referenced as: UNDP (2014). *Tunisia: Derisking Renewable Energy Investment*. New York, NY: United Nations Development Programme.

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This document is an accompaniment to the full report. The full report contains the findings of the base case scenarios for wind energy and solar PV, as well as an executive summary, an overview of the approach taken, and full details on the methodology and data used.

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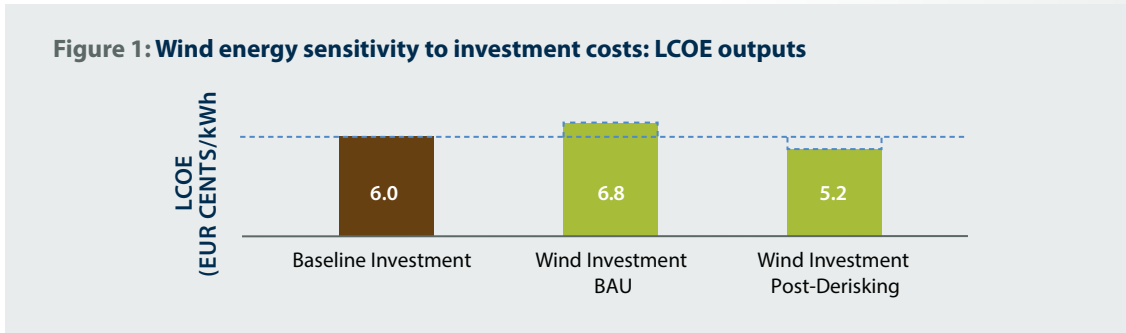
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Wind Energy Sensitivity Analysis

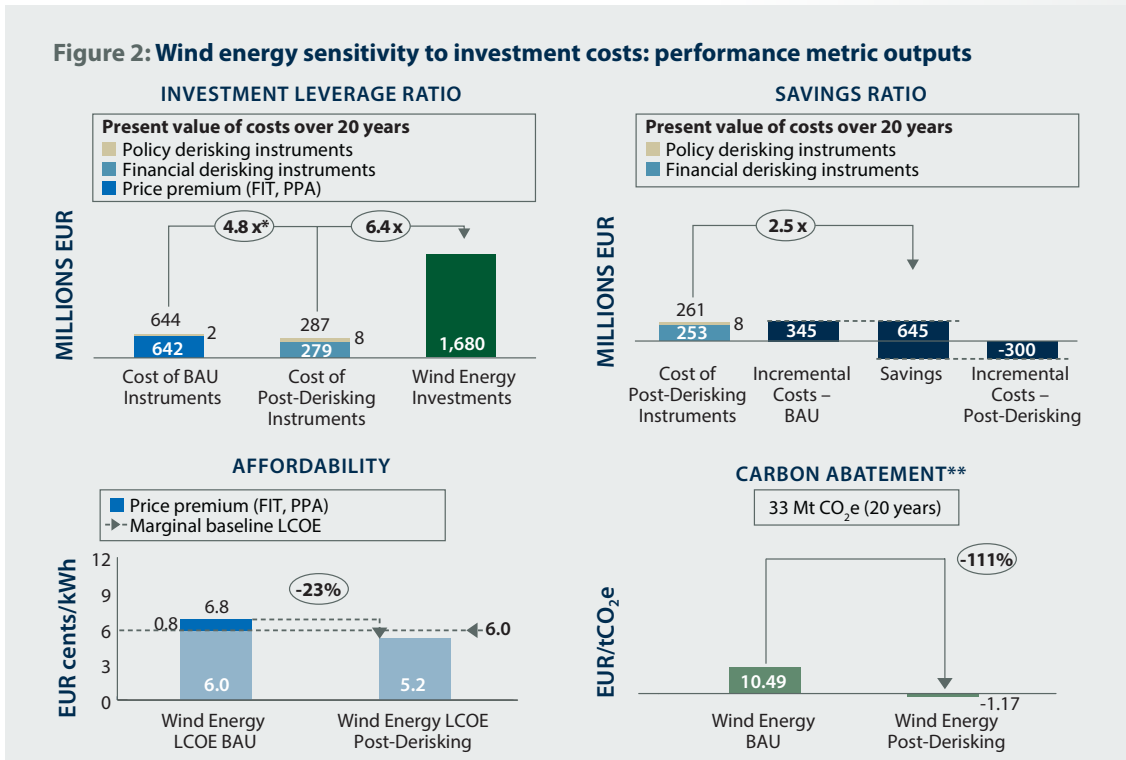
1.1 SENSITIVITY TO WIND ENERGY INVESTMENT COSTS

This sensitivity provides an indication of the impacts of continuing falls in technology costs.

- The model base case scenario uses 2014 technology costs for wind energy at EUR 1.240 million/MW.
- This sensitivity uses 2022¹ technology costs for wind energy at EUR 1.116 million/MW.



Source: modelling; see Table 7 and Annex A in the full report for details of assumptions and methodology.



Source: modelling; see Table 7 and Annex A in the full report for details of assumptions and methodology.

* In the BAU scenario, the full 2030 investment target may not be met.

**Carbon abatement figure components: Business-as-usual, policy derisking instruments EUR 0.05, financial derisking instruments EUR 0.00, price premium EUR 14.45. Post-derisking 0.26, EUR 7.65 and EUR -9.07 respectively.

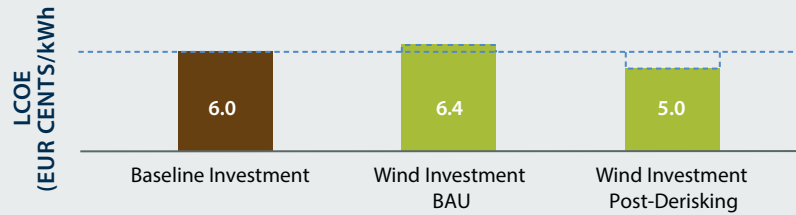
¹ 2022 is the mid-point between 2014-2030, the modelling period, and, as such, an estimate of 2022 costs acts as a proxy for average investment costs over the 2014-2030 period.

1.2 SENSITIVITY TO WIND ENERGY CAPACITY FACTOR

This sensitivity provides an indication of the impacts of a higher capacity factor for wind energy.

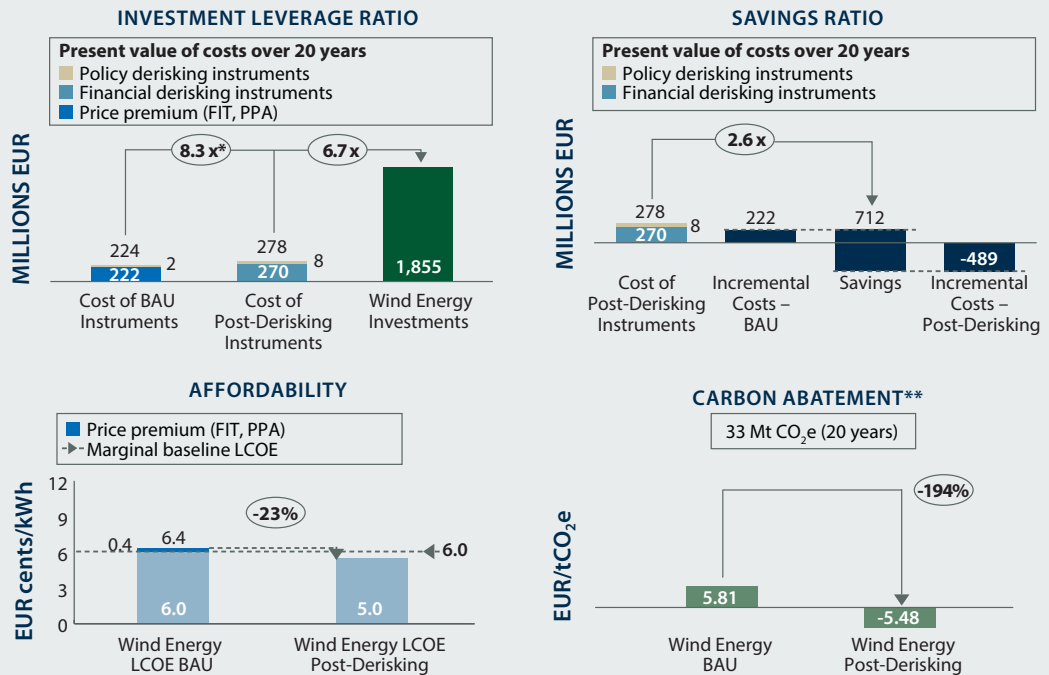
- The modelling uses a capacity factor for wind energy estimated at 30%.
- This sensitivity uses a capacity factor for wind energy estimated at 35%.

Figure 3: Wind energy sensitivity to capacity factor: LCOE outputs



Source: modelling; see Table 7 and Annex A in the full report for details of assumptions and methodology.

Figure 4: Wind energy sensitivity to capacity factor: performance metric outputs



Source: modelling; see Table 7 and Annex A in the full report for details of assumptions and methodology.

* In the BAU scenario, the full 2030 investment target may not be met.

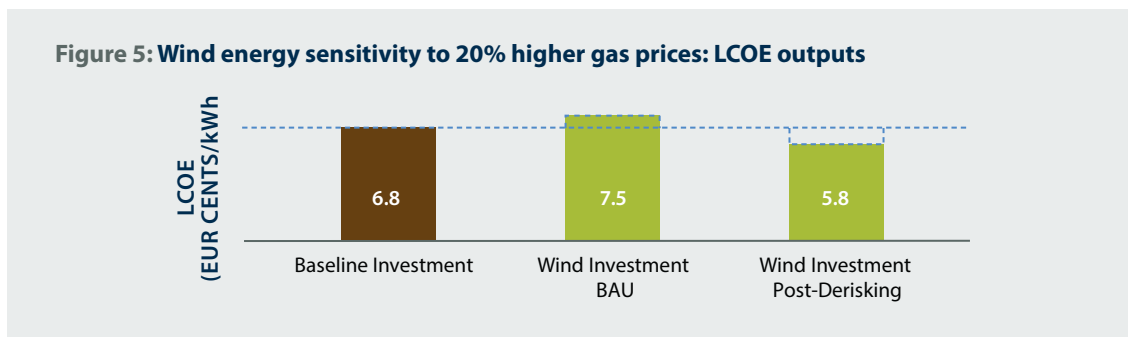
**Carbon abatement figure components: Business-as-usual, policy derisking instruments EUR 0.04, financial derisking instruments EUR 0.00, price premium EUR 5.77. Post-derisking, EUR 0.22, EUR 7.00 and EUR -12.69 respectively.

1.3 SENSITIVITY TO GAS FUEL COSTS

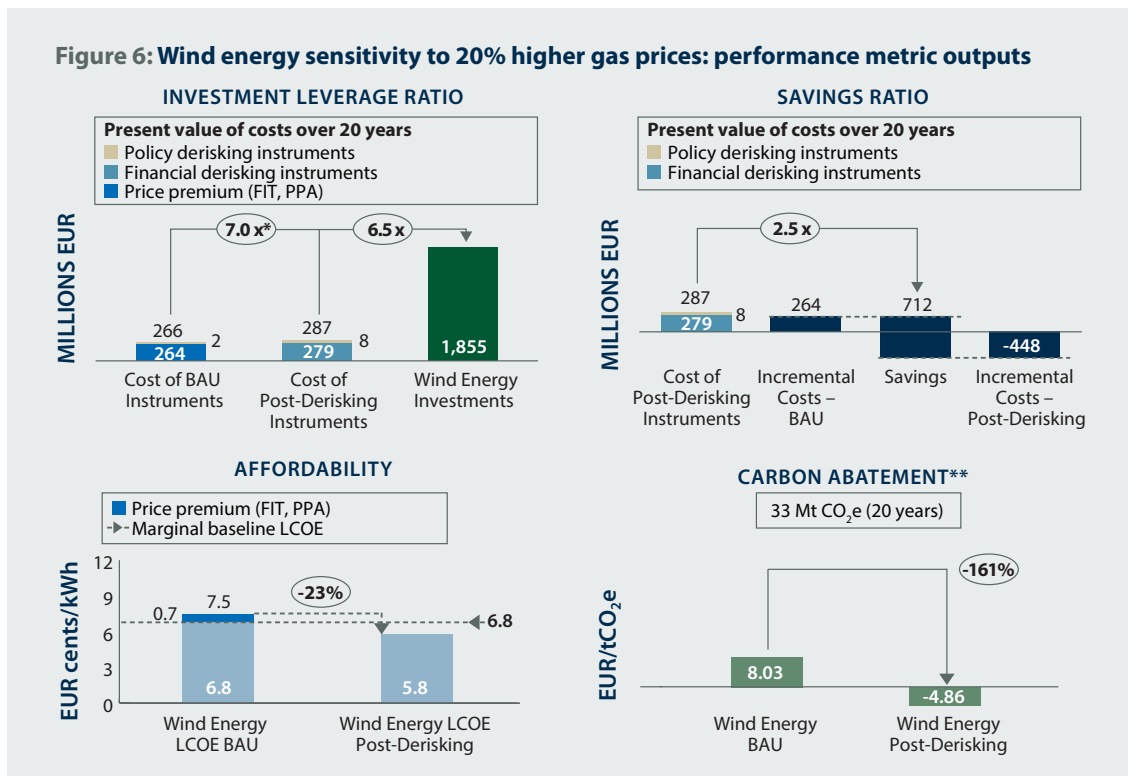
This sensitivity provides an indication of the impacts of higher or lower gas prices on baseline energy costs.

- The modelling uses STEG’s current 2014 gas prices for IPPs, and then projects these going forward using the trend from the IEA World Economic Outlook (2013) projections.
- This sensitivity looks at two scenarios:
 - The first scenario raises the IEA gas price projections by 20% each year.
 - The second scenario lowers the IEA gas price projections by 20% each year.

1.3.1 Sensitivity to 20% Higher Gas Prices



Source: modelling; see Table 7 and Annex A in the full report for details of assumptions and methodology.



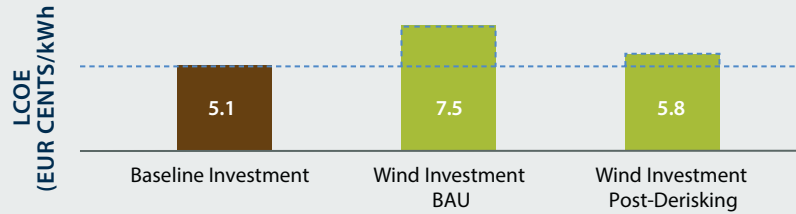
Source: modelling; see Table 7 and Annex A in the full report for details of assumptions and methodology.

* In the BAU scenario, the full 2030 investment target may not be met.

**Carbon abatement figure components: Business-as-usual, policy derisking instruments EUR 0.05, financial derisking instruments EUR 0.00, price premium EUR 7.99. Post-derisking, EUR 0.26, EUR 8.44 and EUR -13.55 respectively.

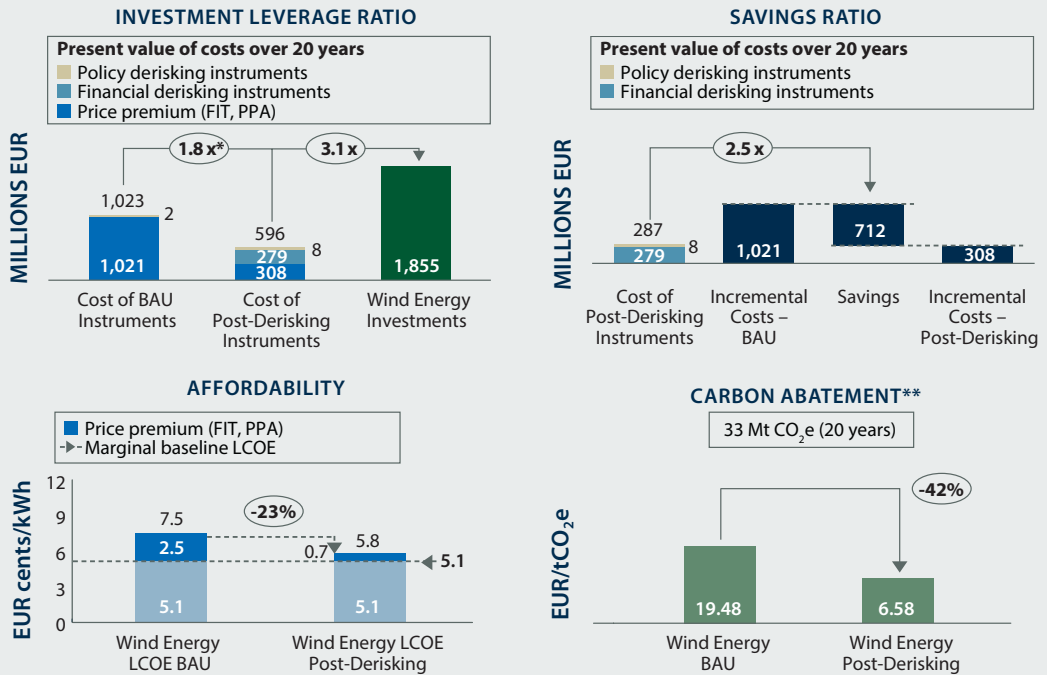
1.3.2 Sensitivity to 20% Lower Gas Prices

Figure 7: Wind energy sensitivity to 20% lower gas prices: LCOE outputs



Source: modelling; see Table 7 and Annex A in the full report for details of assumptions and methodology.

Figure 8: Wind energy sensitivity to 20% lower gas prices: performance metric outputs



Source: modelling; see Table 7 and Annex A in the full report for details of assumptions and methodology.

* In the BAU scenario, the full 2030 investment target may not be met.

**Carbon abatement figure components: Business-as-usual, policy derisking instruments EUR 0.05, financial derisking instruments EUR 0.00, price premium EUR 30.87. Post-derisking, EUR 0.26, EUR 8.44 and EUR 9.33 respectively.

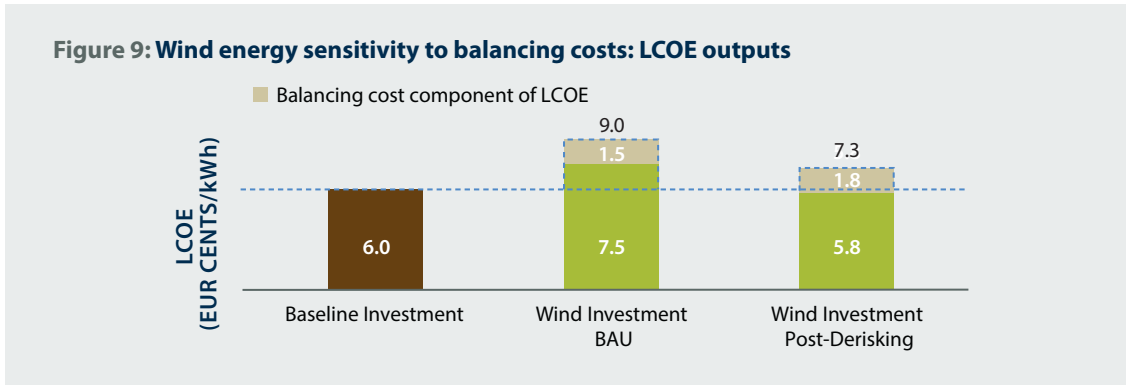
Figure 10: Wind energy sensitivity to balancing costs: performance metric outputs

1.4 SENSITIVITY TO BALANCING COSTS

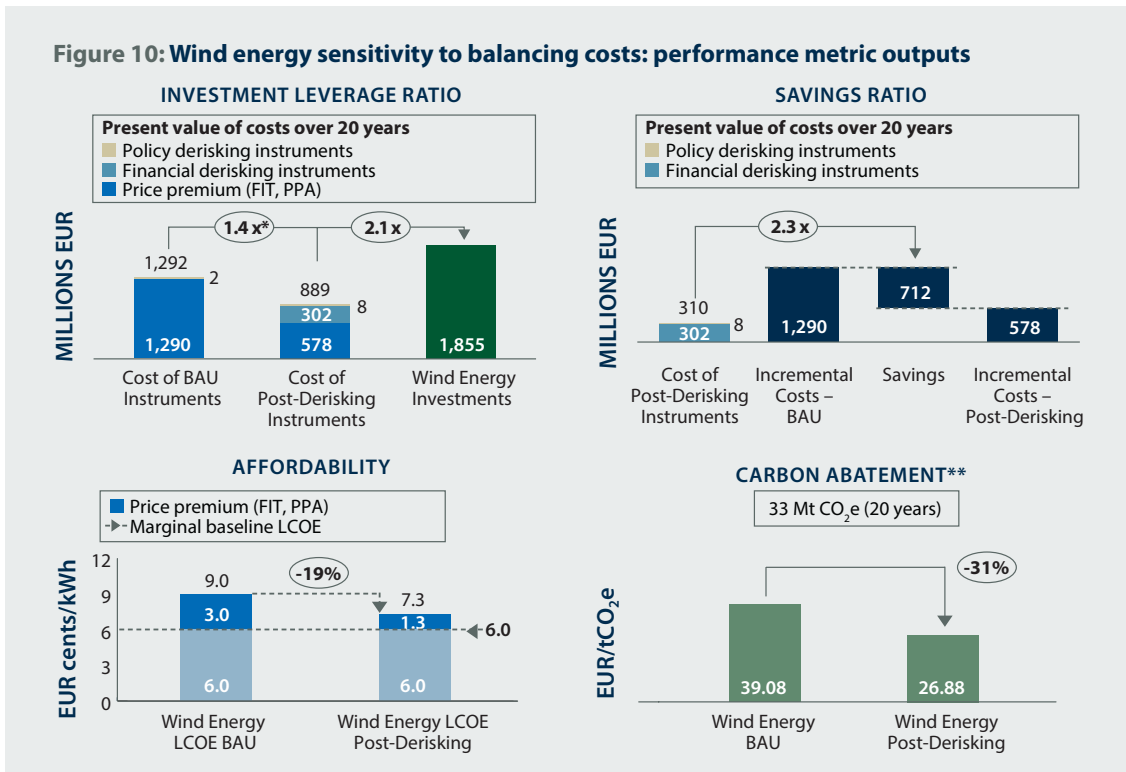
This sensitivity provides an indication of the impact of including balancing costs for wind energy.

- The model base case does not include balancing costs.
- This sensitivity includes balancing costs.

Balancing costs reflect the cost to the Tunisian power system as a whole of managing the variability of renewable energy. This includes the both the capital costs of reserve gas (CCGT) plants and their lower efficiencies when utilised.



Source: modelling; see Table 7 and Annex A in the full report for details of assumptions and methodology.



Source: modelling; see Table 7 and Annex A in the full report for details of assumptions and methodology.

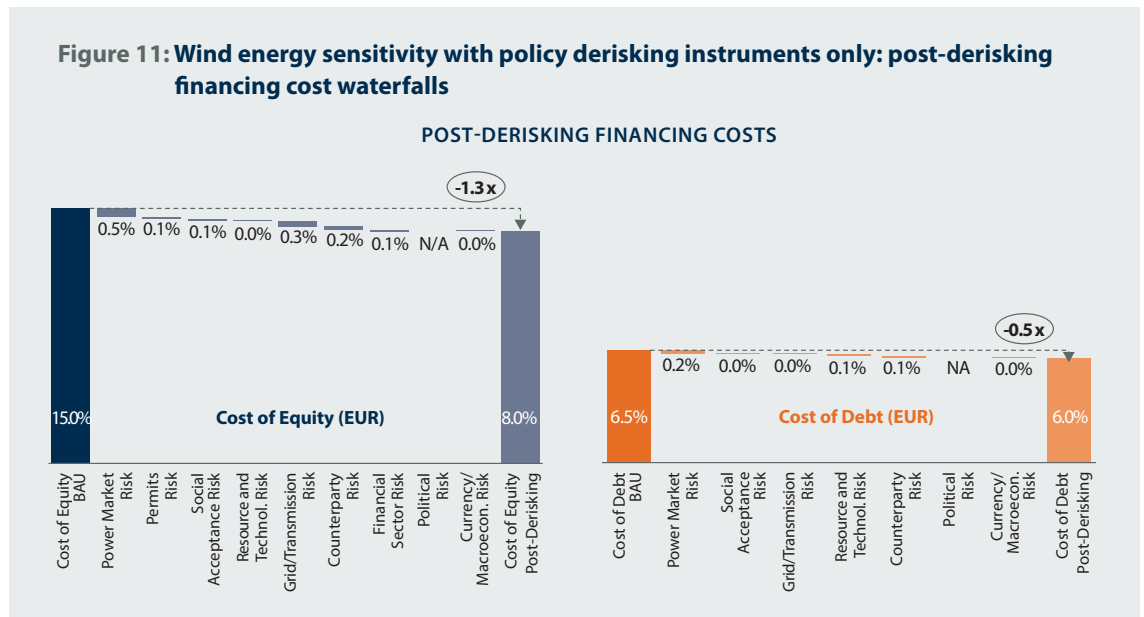
* In the BAU scenario, the full 2030 investment target may not be met.

**Carbon abatement figure components: Business-as-usual, policy derisking instruments EUR 0.05, financial derisking instruments EUR 0.00, price premium EUR 39.03. Post-derisking, EUR 0.26, EUR 9.13 and EUR 17.49 respectively.

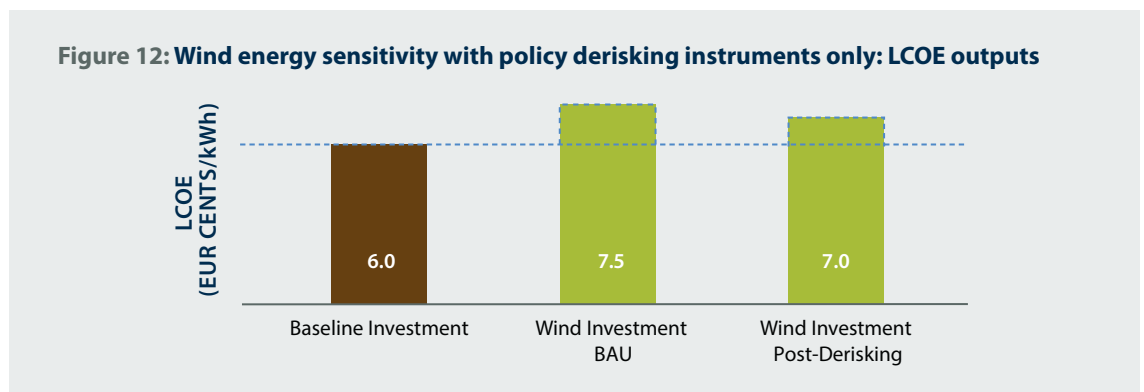
1.5 SENSITIVITY TO POLICY DERISKING INSTRUMENTS ONLY

This sensitivity provides an indication of the impacts of an instrument package focused solely on policy derisking measures:

- The model base case includes both policy derisking (EUR 8.5 million) and financial derisking instruments (EUR 279.0 million).
- This sensitivity uses only policy derisking instruments (EUR 8.5 million). The list of policy derisking instruments can be found in Table 7 of the full report.

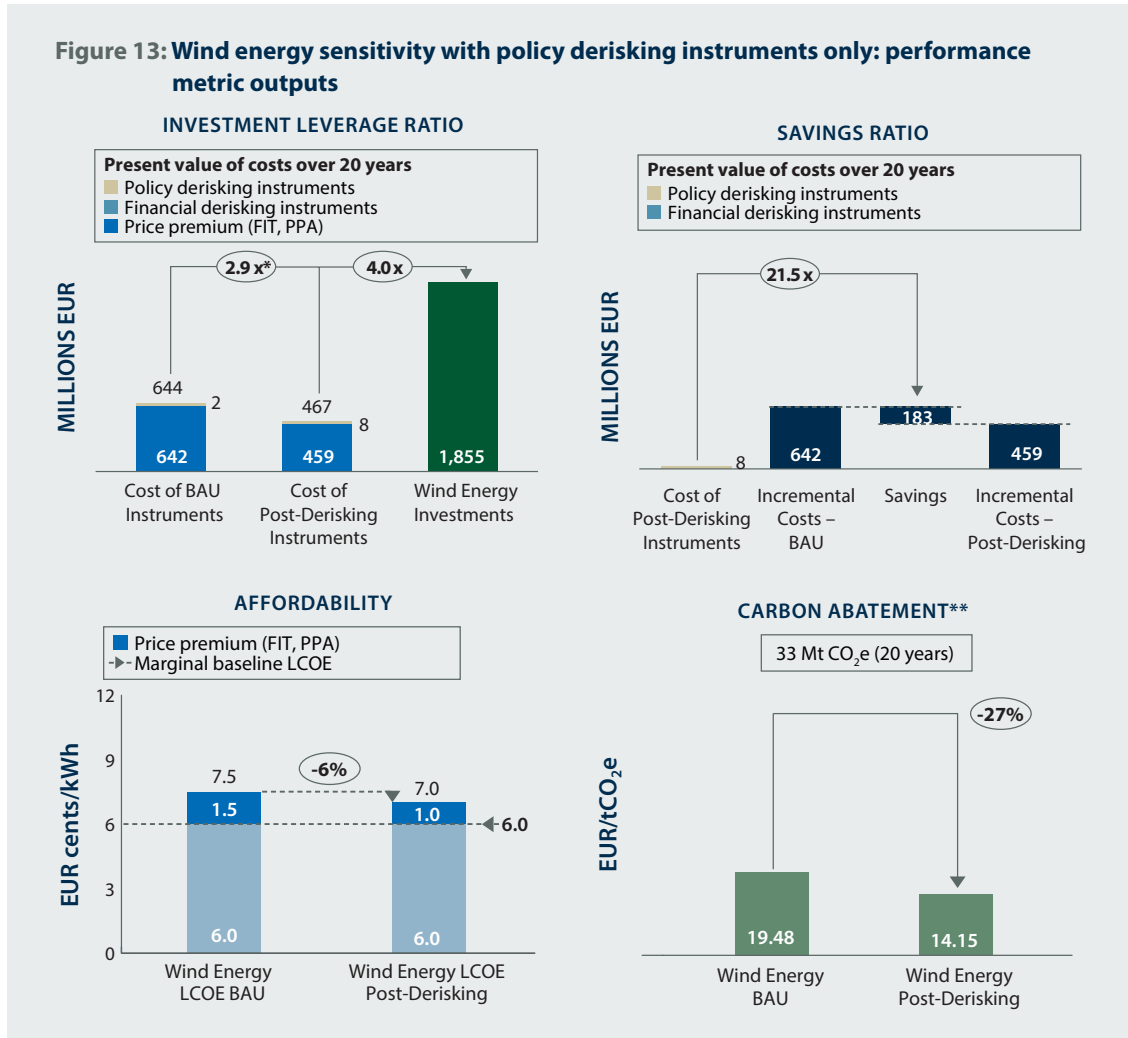


Source: interviews with wind energy and solar PV investors and developers; modelling; see Annex C for details of assumptions and methodology. Note: the impacts shown are average impacts over the 2014-2030 modelling period, assuming linear timing effects.



Source: modelling; see Table 7 and Annex A in the full report for details of assumptions and methodology.

Figure 13: Wind energy sensitivity with policy derisking instruments only: performance metric outputs



Source: modelling; see Table 7 and Annex A in the full report for details of assumptions and methodology.

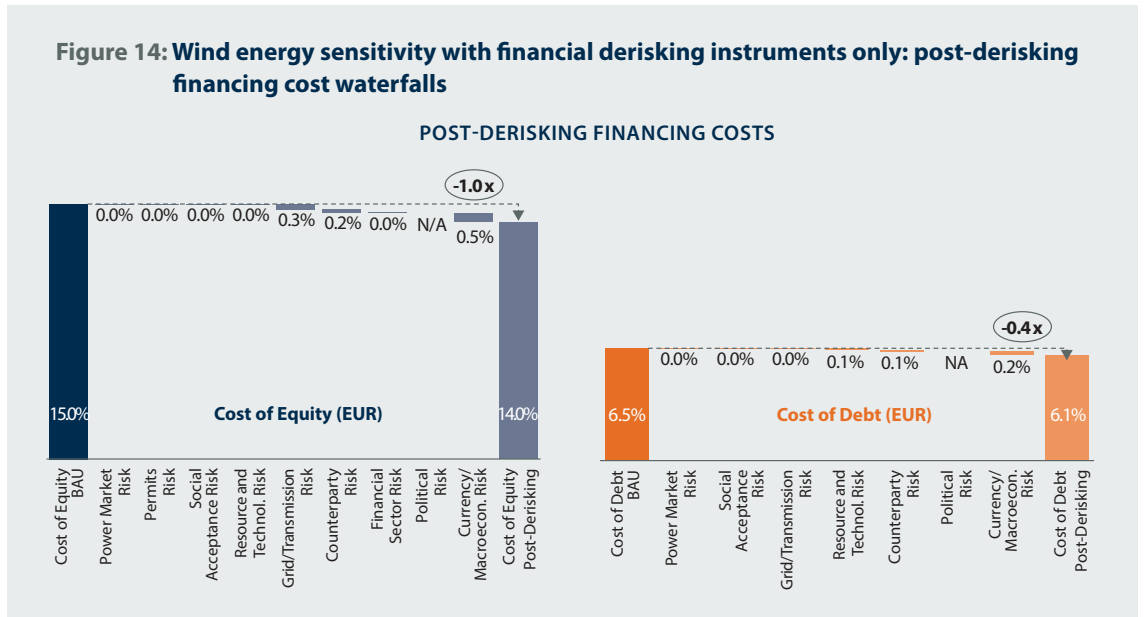
* In the BAU scenario, the full 2030 investment target may not be met.

**Carbon abatement figure components: Business-as-usual, policy derisking instruments EUR 0.05, financial derisking instruments EUR 0.00, price premium EUR 19.43. Post-derisking, EUR 0.26, EUR 0.00 and EUR 13.89 respectively.

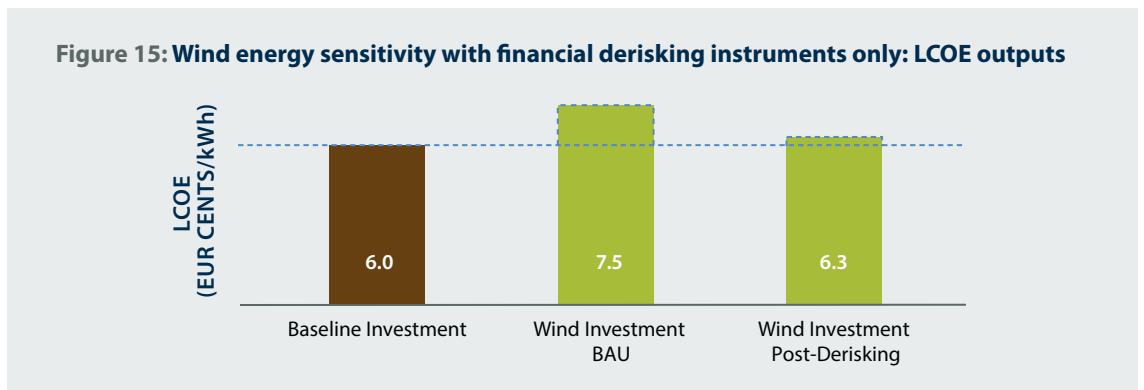
1.6 SENSITIVITY TO FINANCIAL DERISKING INSTRUMENTS ONLY

This sensitivity provides an indication of the impacts of an instrument package focused solely on financial derisking measures:

- The model base case includes both policy derisking (EUR 8.5 million) and financial derisking instruments (EUR 279.0 million).
- This sensitivity uses only financial derisking instruments (EUR 279.0 million). The list of financial derisking instruments can be found in Table 7 of the full report.

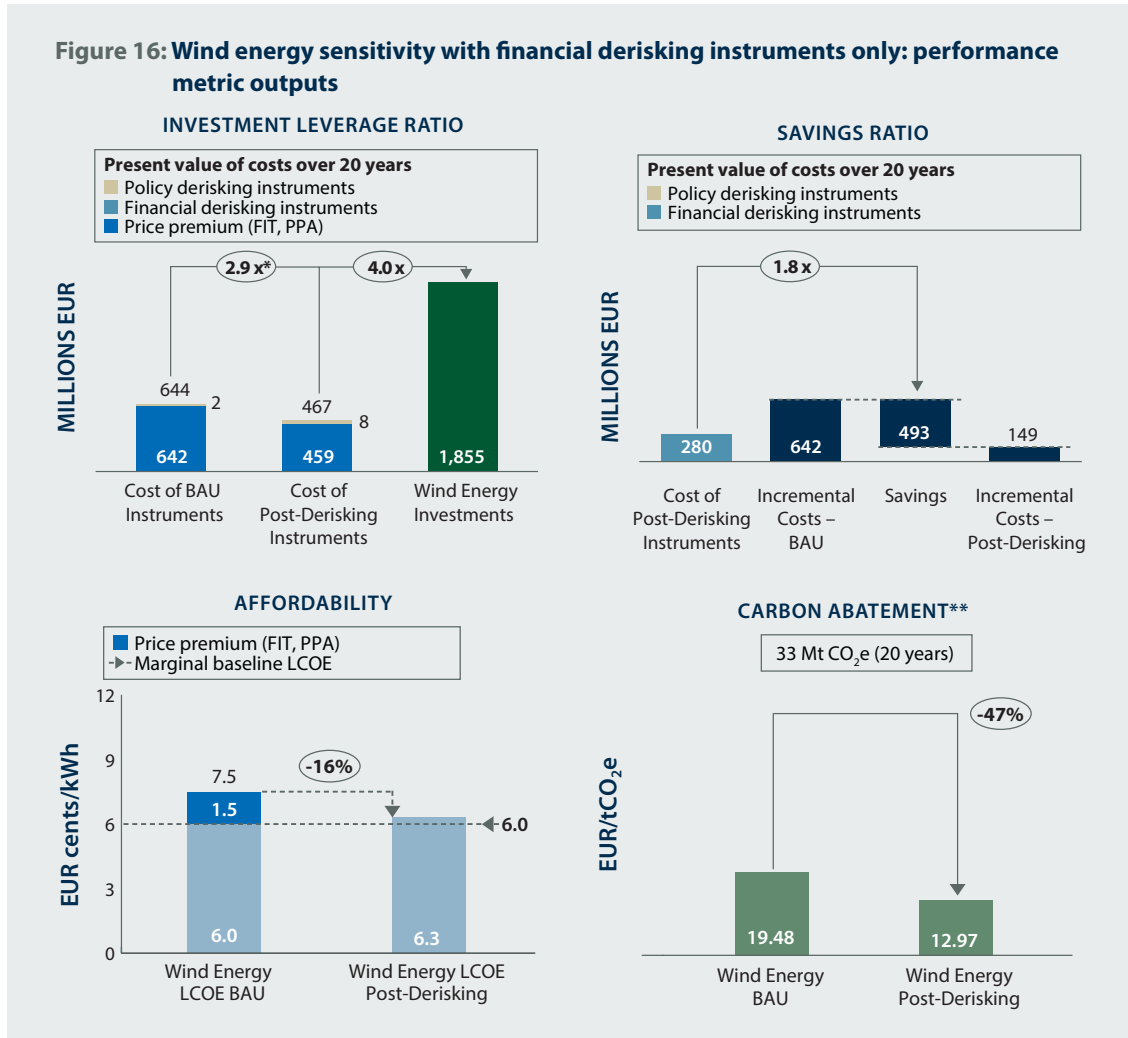


Source: interviews with wind energy and solar PV investors and developers; modelling; see Annex C for details of assumptions and methodology. Note: the impacts shown are average impacts over the 2014-2030 modelling period, assuming linear timing effects.



Source: modelling; see Table 7 and Annex A in the full report for details of assumptions and methodology.

Figure 16: Wind energy sensitivity with financial derisking instruments only: performance metric outputs



Source: modelling; see Table 7 and Annex A in the full report for details of assumptions and methodology.

* In the BAU scenario, the full 2030 investment target may not be met.

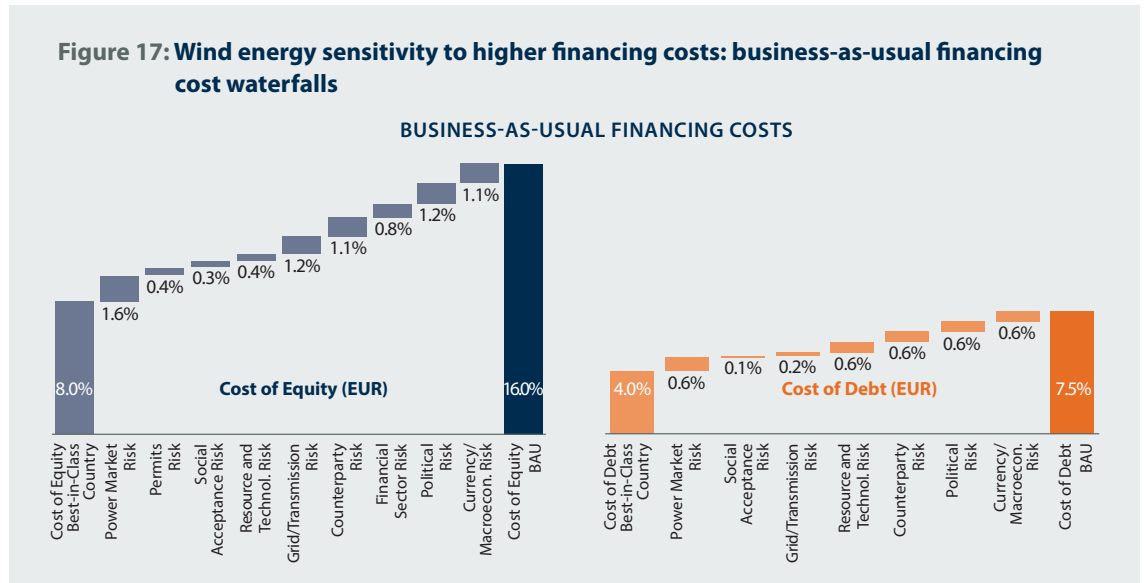
**Carbon abatement figure components: Business-as-usual, policy derisking instruments EUR 0.05, financial derisking instruments EUR 0.00, price premium EUR 19.43. Post-derisking, EUR 0.26, EUR 0.00 and EUR 13.89 respectively.

1.7 SENSITIVITY TO FINANCING COSTS

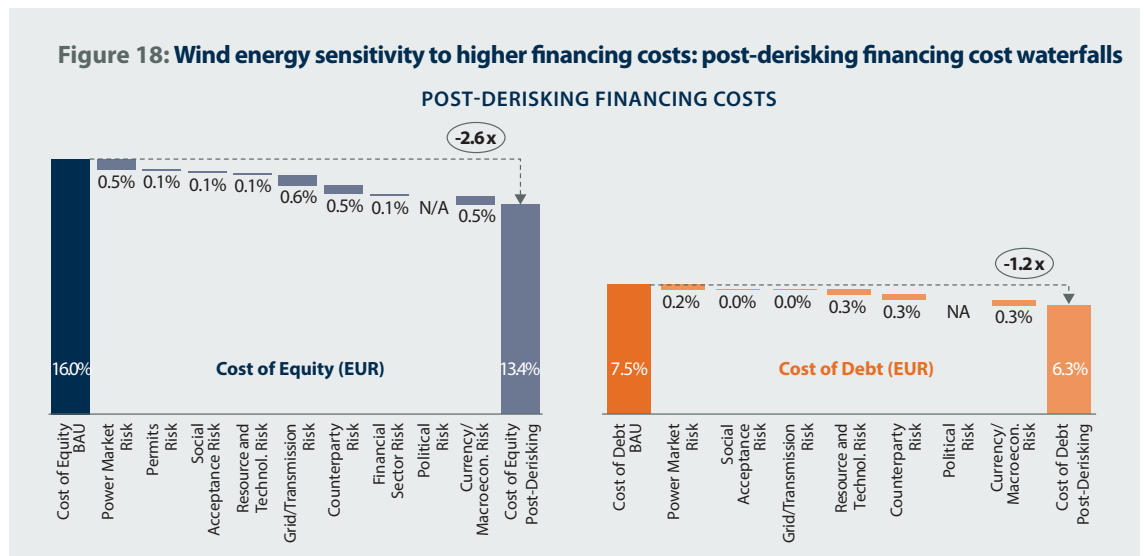
This sensitivity provides an indication of the impacts of higher or lower financing costs.

- The model base case assumes a 15.0% cost of equity (EUR) and a 6.5% cost of debt (EUR) in Tunisia.
- This sensitivity looks at two scenarios:
 - A scenario in which the financing costs are increased by 1% (100 basis points). The cost of equity is 16.0% (EUR) and the cost of debt is 7.5% (EUR).
 - A scenario in which the financing costs are reduced by 1% (100 basis points). The cost of equity is 14.0% (EUR) and the cost of debt is 5.5% (EUR).

1.7.1 Sensitivity to +1% Financing Costs

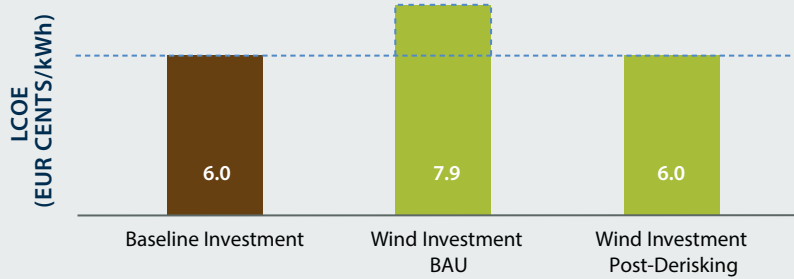


Source: interviews with wind energy and solar PV investors and developers; modelling; best-in-class country is assumed to be Germany; see Annex C for details of assumptions and methodology.



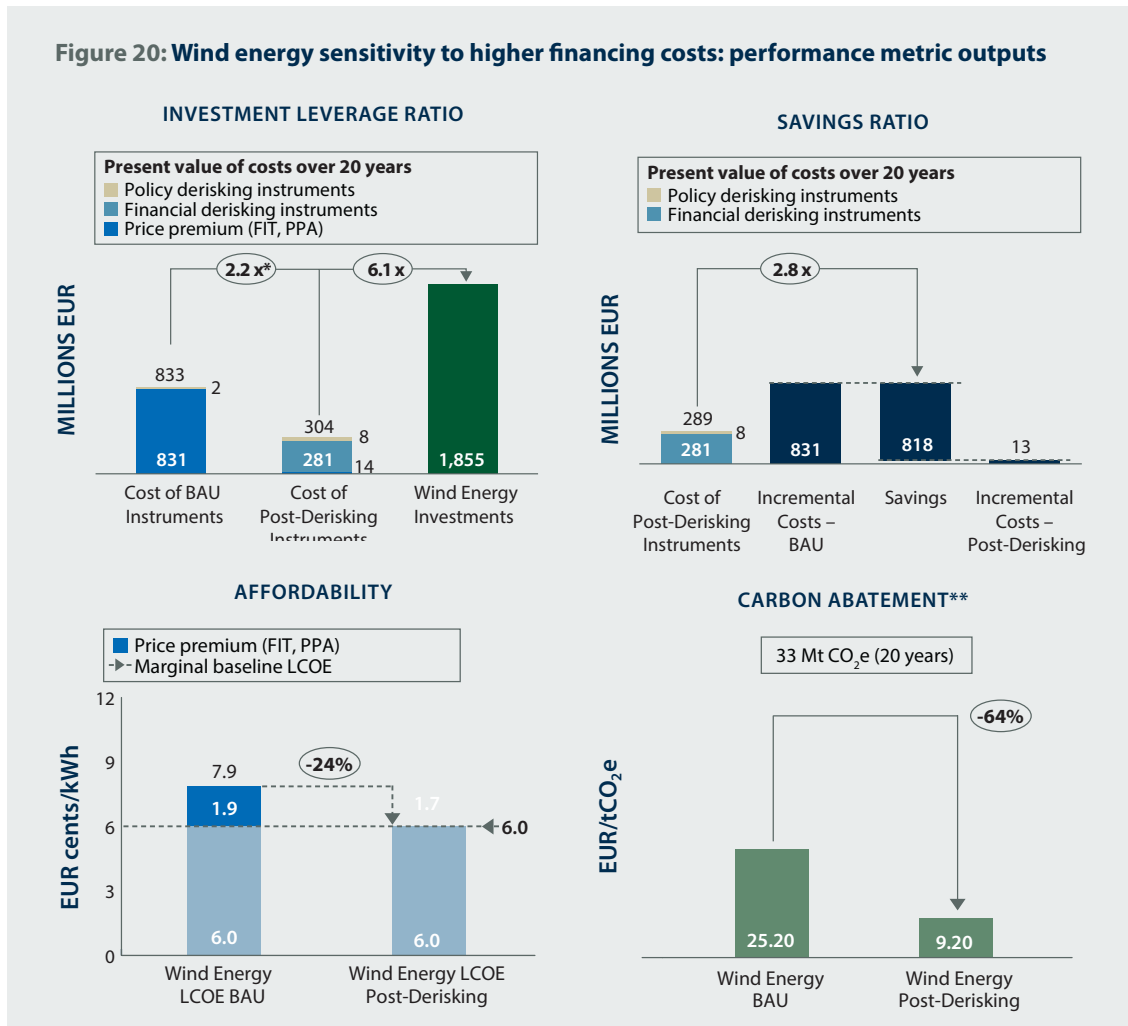
Source: interviews with wind energy and solar PV investors and developers; modelling; see Annex C for details of assumptions and methodology. Note: the impacts shown are average impacts over the 2014-2030 modelling period, assuming linear timing effects.

Figure 19: Wind energy sensitivity to higher financing costs: LCOE outputs



Source: modelling; see Table 7 and Annex A in the full report for details of assumptions and methodology.

Figure 20: Wind energy sensitivity to higher financing costs: performance metric outputs

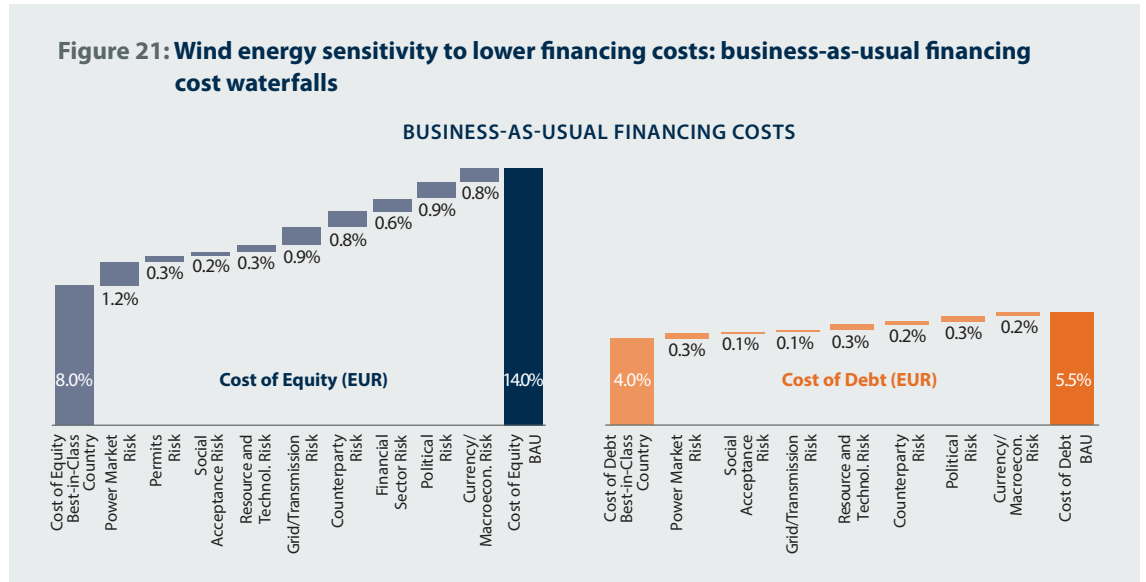


Source: modelling; see Table 7 and Annex A in the full report for details of assumptions and methodology.

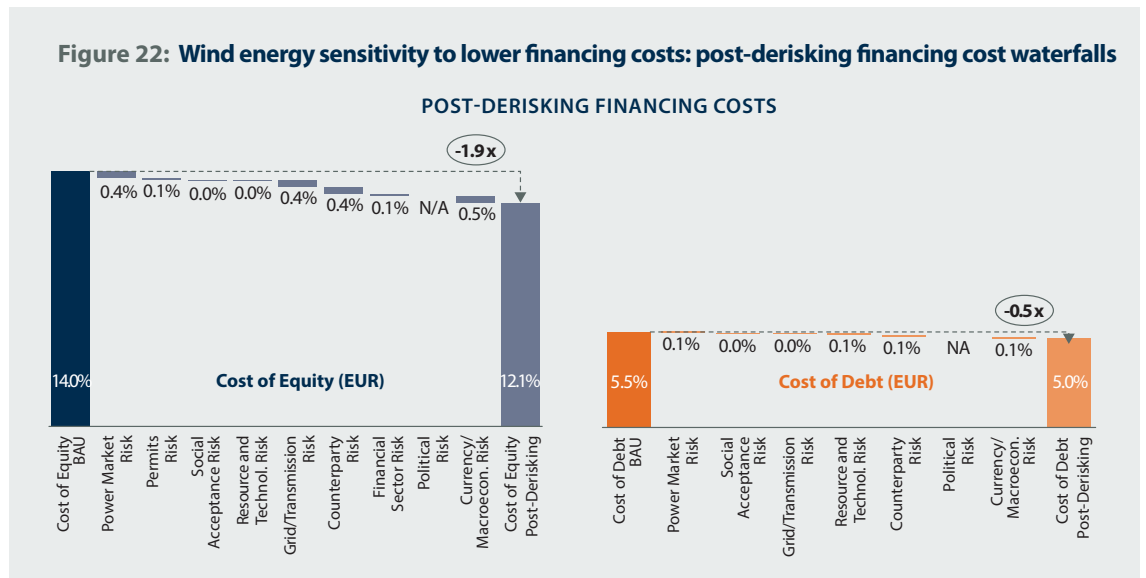
* In the BAU scenario, the full 2030 investment target may not be met.

**Carbon abatement figure components: Business-as-usual, policy derisking instruments EUR 0.05, financial derisking instruments EUR 0.00, price premium EUR 25.15. Post-derisking, EUR 0.26, EUR 8.53 and EUR 0.41 respectively.

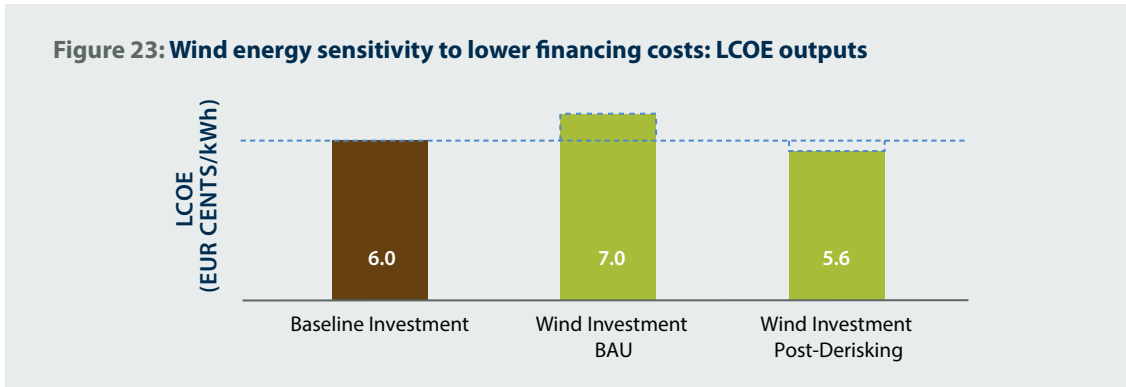
1.7.2 Sensitivity to -1% Financing Costs



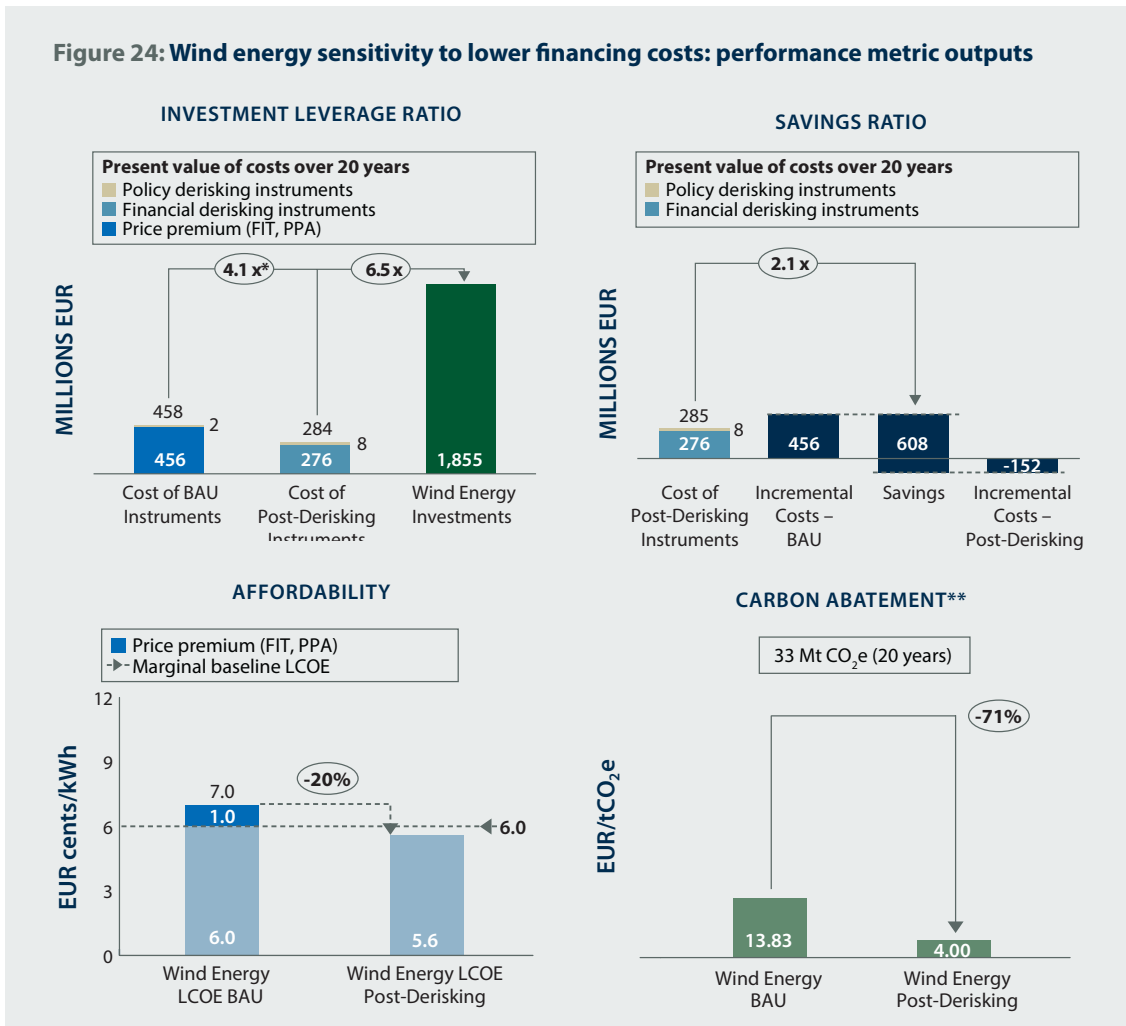
Source: interviews with wind energy and solar PV investors and developers; modelling; best-in-class country is assumed to be Germany; see Annex C for details of assumptions and methodology.



Source: interviews with wind energy and solar PV investors and developers; modelling; see Annex C for details of assumptions and methodology. Note: the impacts shown are average impacts over the 2014-2030 modelling period, assuming linear timing effects.



Source: modelling; see Table 7 and Annex A in the full report for details of assumptions and methodology.



Source: modelling; see Table 7 and Annex A in the full report for details of assumptions and methodology.

* In the BAU scenario, the full 2030 investment target may not be met.

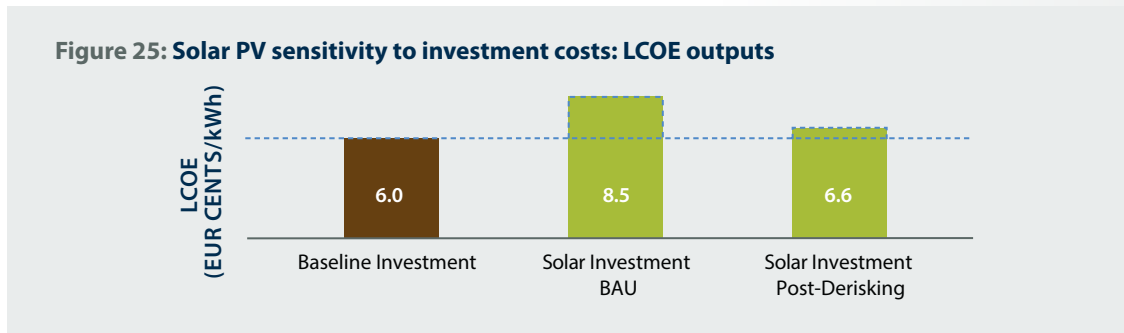
**Carbon abatement figure components: Business-as-usual, policy derisking instruments EUR 0.05, financial derisking instruments EUR 0.00, price premium EUR 13.78. Post-derisking, EUR 0.26, EUR 8.35 and EUR -4.61 respectively.

Solar PV Sensitivity Analysis

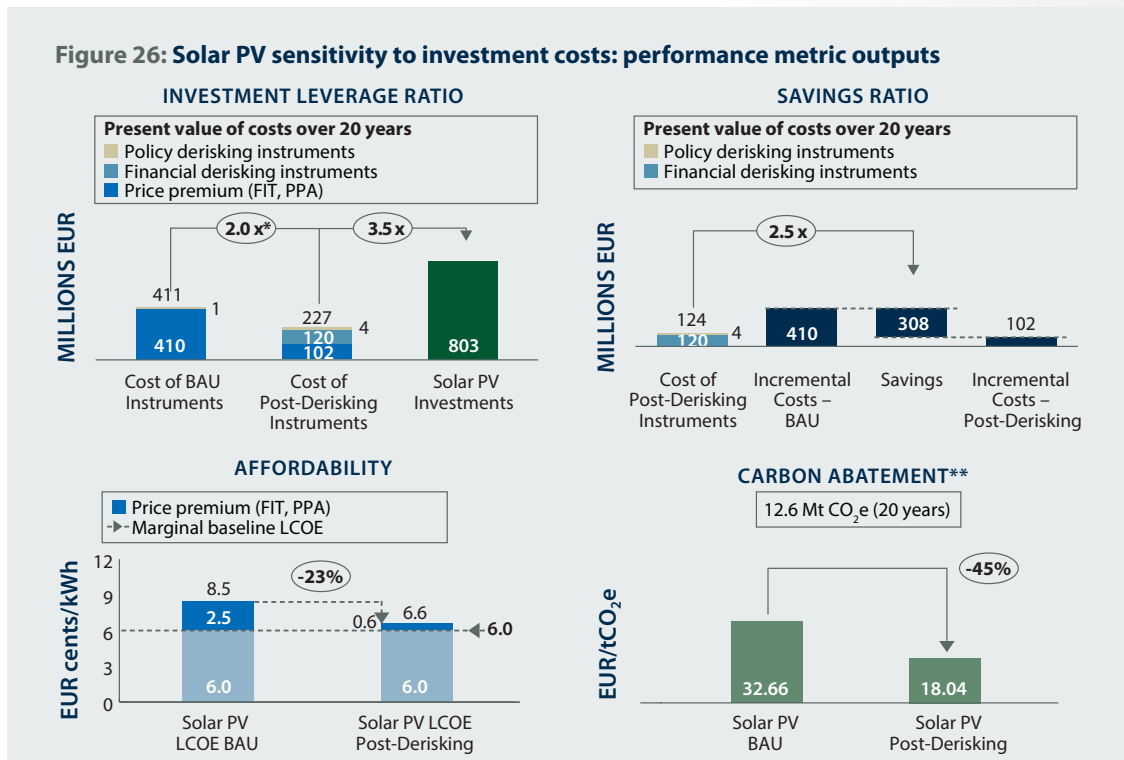
2.1 SENSITIVITY TO SOLAR PV INVESTMENT COSTS

This sensitivity provides an indication of the impacts of continuing falls in technology costs.

- The model's base case uses 2014 technology costs for solar PV at EUR 1.189 million/MW.
- This sensitivity uses 2022² technology costs for solar PV at EUR 1.011 million/MW.



Source: modelling; see Table 8 and Annex A in the full report for details of assumptions and methodology.



Source: modelling; see Table 8 and Annex A in the full report for details of assumptions and methodology.

* In the BAU scenario, the full 2030 investment target may not be met.

**Carbon abatement figure components: Business-as-usual, policy derisking instruments EUR 0.06, financial derisking instruments EUR 0.00, price premium EUR 32.60. Post-derisking, EUR 0.35, EUR 9.60 and EUR 8.09 respectively.

² 2022 is the mid-point between 2014-2030, the modelling period, and, as such, an estimate of 2022 costs acts as a proxy for average investment costs over the 2014-2030 period.

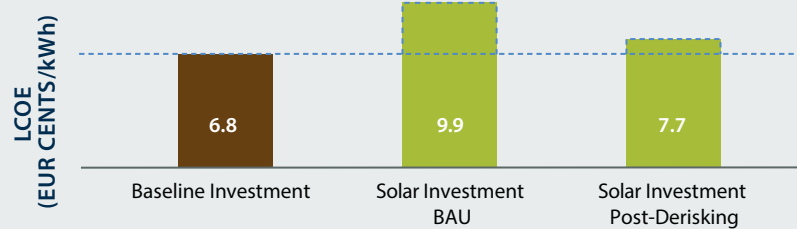
2.2 SENSITIVITY TO GAS FUEL COSTS

This sensitivity provides an indication of the impacts of higher or lower gas prices on baseline energy costs.

- The model uses STEG’s current 2014 gas prices for IPPs, and then projects these going forward using the trend from the IEA World Economic Outlook (2013) projections.
- This sensitivity looks at two scenarios:
 - The first scenario raises the IEA gas price projections by 20% each year.
 - The second scenario lowers the IEA gas price projections by 20% each year.

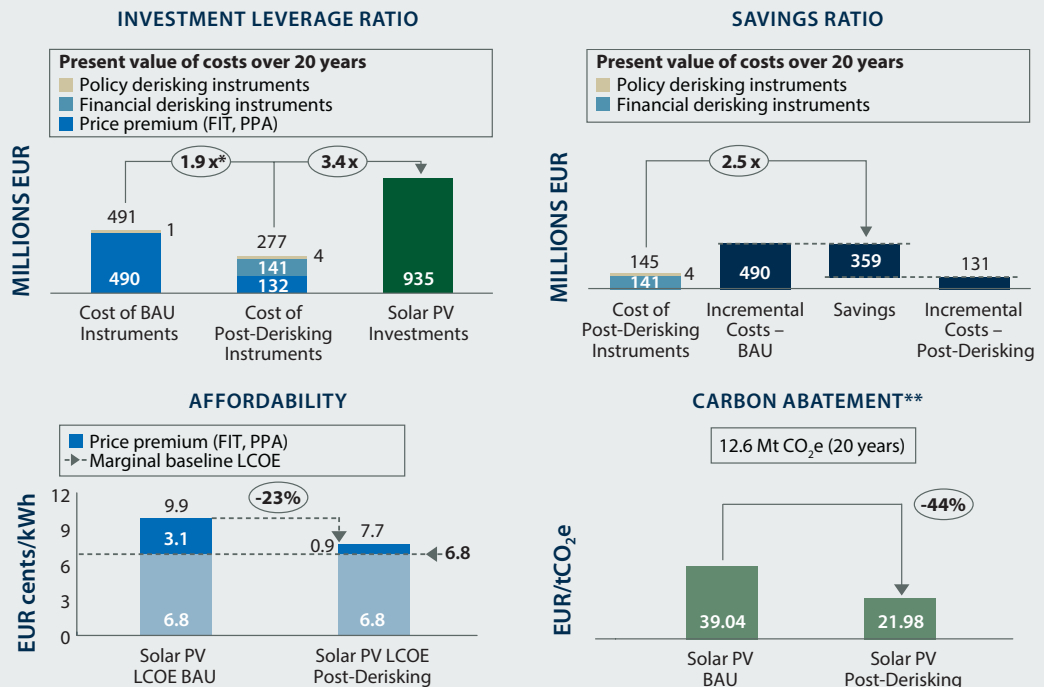
2.2.1 Sensitivity to 20% Higher Gas Prices

Figure 27: Solar PV sensitivity to 20% higher gas prices: LCOE outputs



Source: modelling; see Table 8 and Annex A in the full report for details of assumptions and methodology.

Figure 28: Solar PV sensitivity to 20% higher gas prices: performance metric outputs

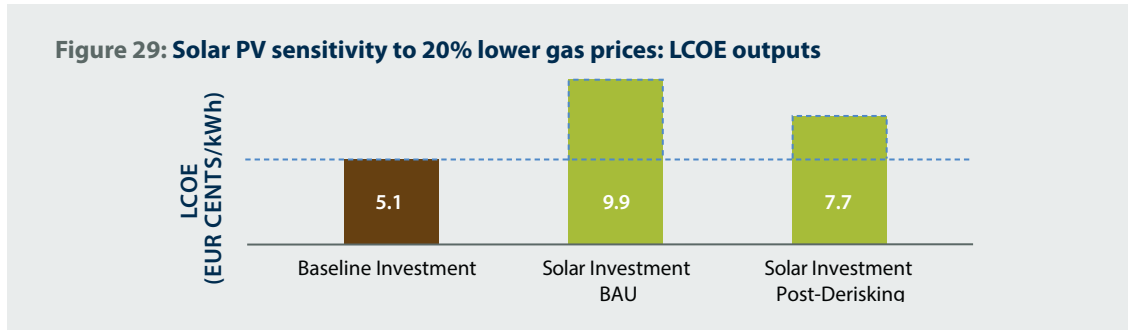


Source: modelling; see Table 8 and Annex A in the full report for details of assumptions and methodology.

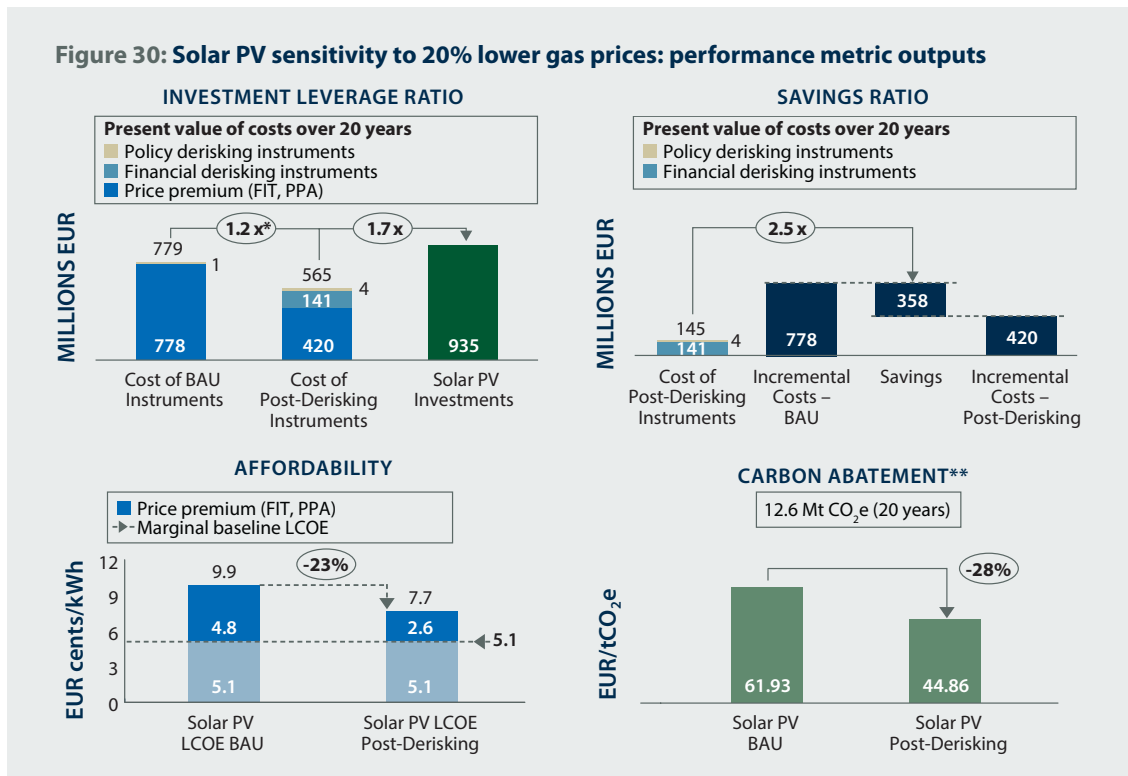
* In the BAU scenario, the full 2030 investment target may not be met.

**Carbon abatement figure components: Business-as-usual, policy derisking instruments EUR 0.06, financial derisking instruments EUR 0.00, price premium EUR 38.98. Post-derisking, EUR 0.35, EUR 11.17 and EUR 10.46 respectively.

2.2.2 Sensitivity to 20% Lower Gas Prices



Source: modelling; see Table 8 and Annex A in the full report for details of assumptions and methodology.



Source: modelling; see Table 8 and Annex A in the full report for details of assumptions and methodology.

* In the BAU scenario, the full 2030 investment target may not be met.

**Carbon abatement figure components: Business-as-usual, policy derisking instruments EUR 0.06, financial derisking instruments EUR 0.00, price premium EUR 61.86. Post-derisking, EUR 0.35, EUR 11.17 and EUR 33.34 respectively.

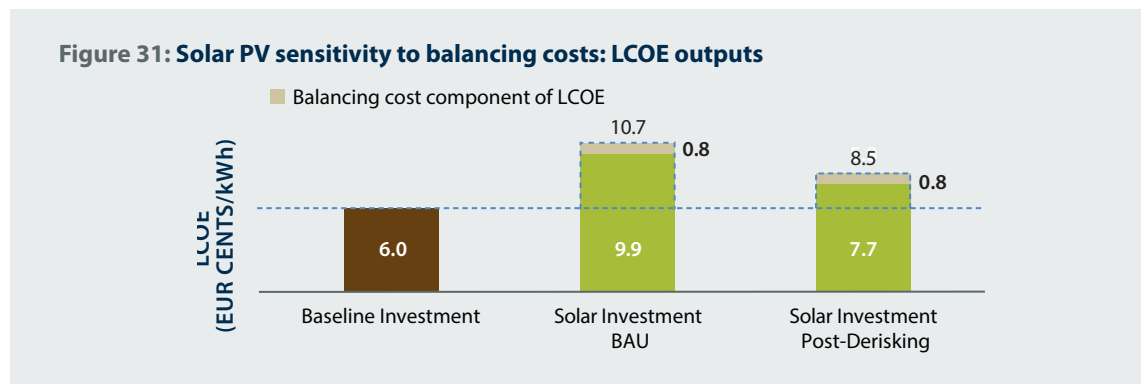
2.3 SENSITIVITY TO BALANCING COSTS

This sensitivity provides an indication of the impacts of including balancing costs for solar PV.

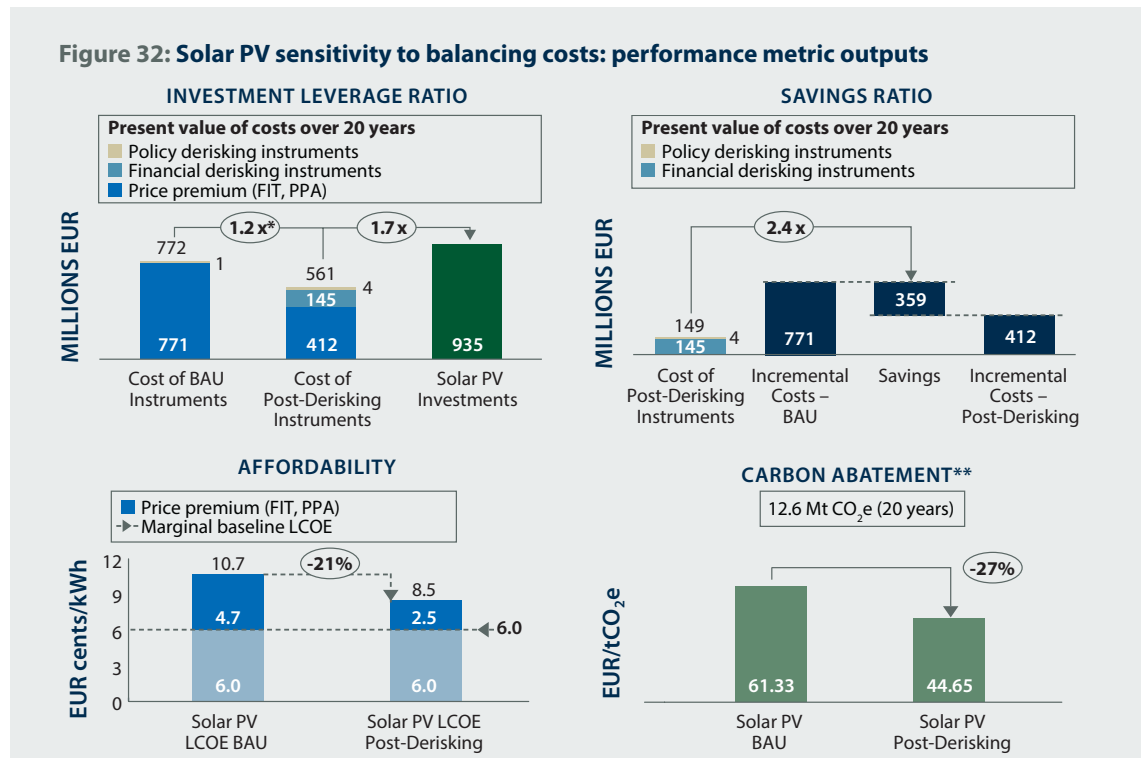
- The model's base case does not include balancing costs.
- This sensitivity includes balancing costs.

Balancing costs reflect the cost to the Tunisian power system as a whole of managing the variability of renewable energy. This includes the both the capital costs of reserve gas (CCGT) plants and their lower efficiencies when utilised.

1.3.1 Sensitivity to 20% Higher Gas Prices



Source: modelling; see Table 8 and Annex A in the full report for details of assumptions and methodology.



Source: modelling; see Table 8 and Annex A in the full report for details of assumptions and methodology.

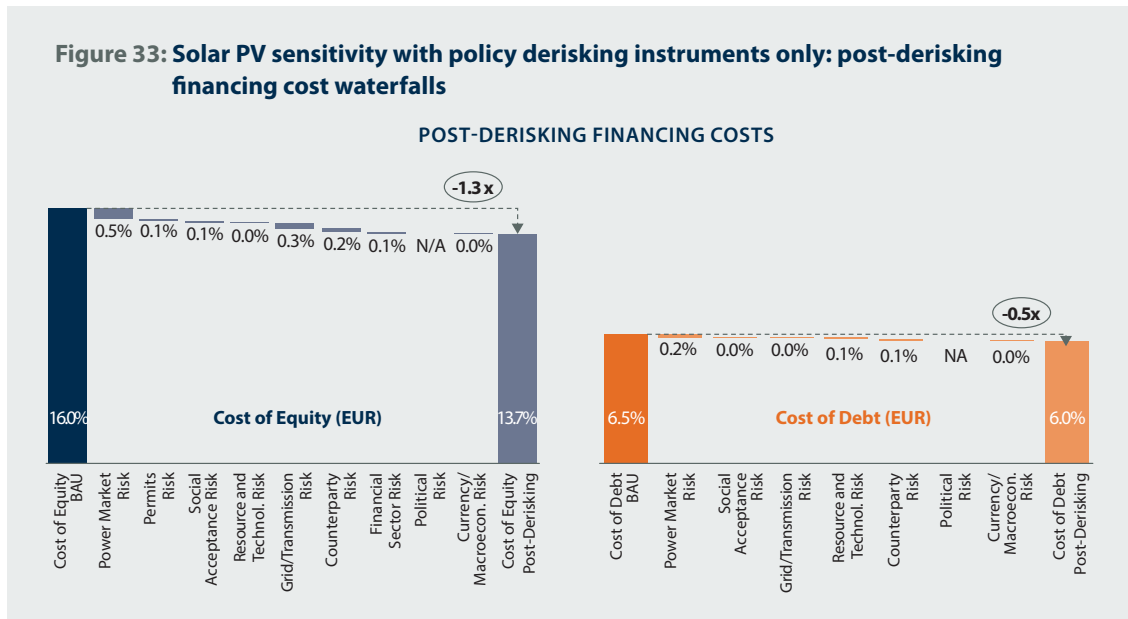
* In the BAU scenario, the full 2030 investment target may not be met.

** Carbon abatement figure components: Business-as-usual, policy derisking instruments EUR 0.06, financial derisking instruments EUR 0.00, price premium EUR 61.27. Post-derisking, EUR 0.35, EUR 11.56 and EUR 32.75 respectively.

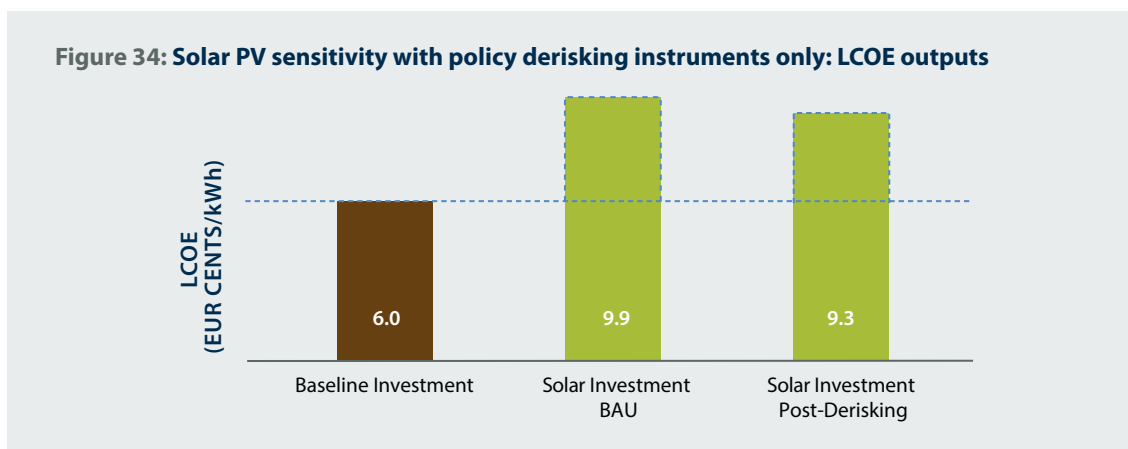
2.4 SENSITIVITY TO POLICY DERISKING INSTRUMENTS ONLY

This sensitivity provides an indication of the impacts of an instrument package focused solely on policy derisking measures:

- The model's base case includes both policy derisking (EUR 4.4 million) and financial derisking instruments (EUR 140.6 million).
- This sensitivity uses only policy derisking instruments (EUR 4.4 million). The list of policy derisking instruments is presented in Table 8 in the full report.

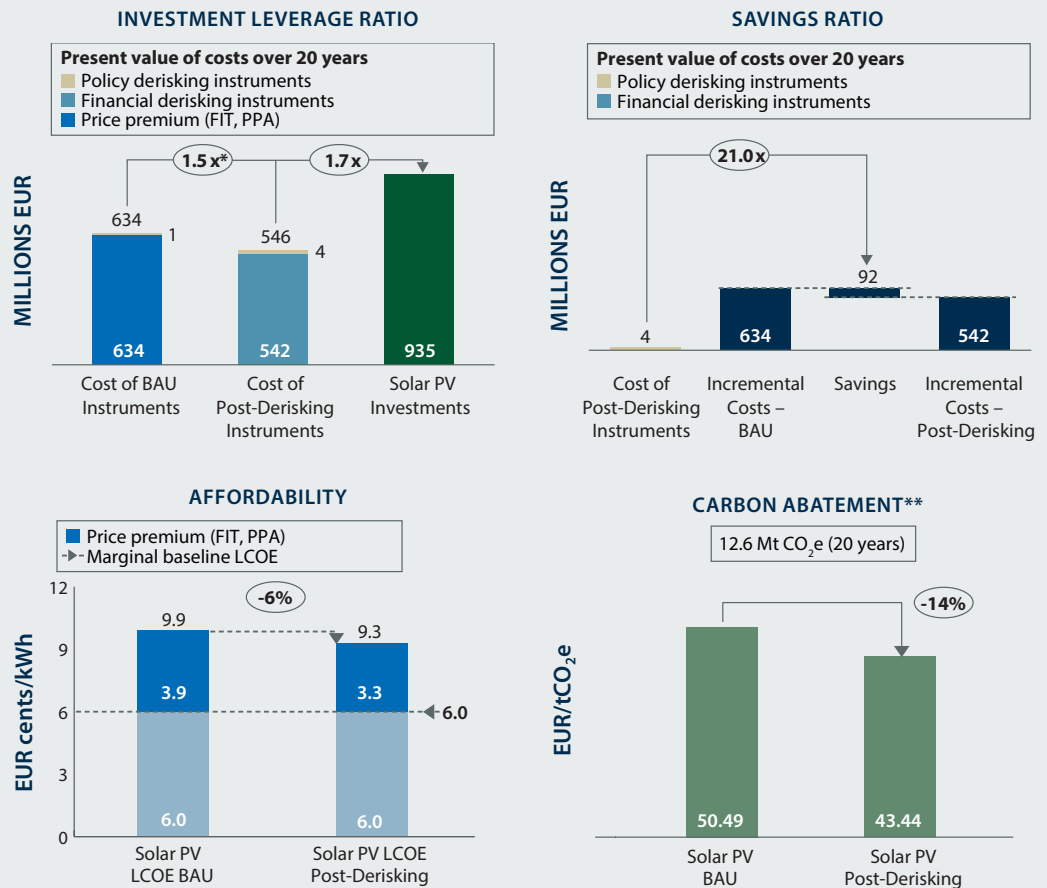


Source: interviews with wind energy and solar PV investors and developers; modelling; see Annex C for details of assumptions and methodology. Note: the impacts shown are average impacts over the 2014-2030 modelling period, assuming linear timing effects.



Source: modelling; see Table 8 and Annex A in the full report for details of assumptions and methodology.

Figure 35: Solar PV sensitivity with policy derisking instruments only: performance metric outputs



Source: modelling; see Table 8 and Annex A in the full report for details of assumptions and methodology.

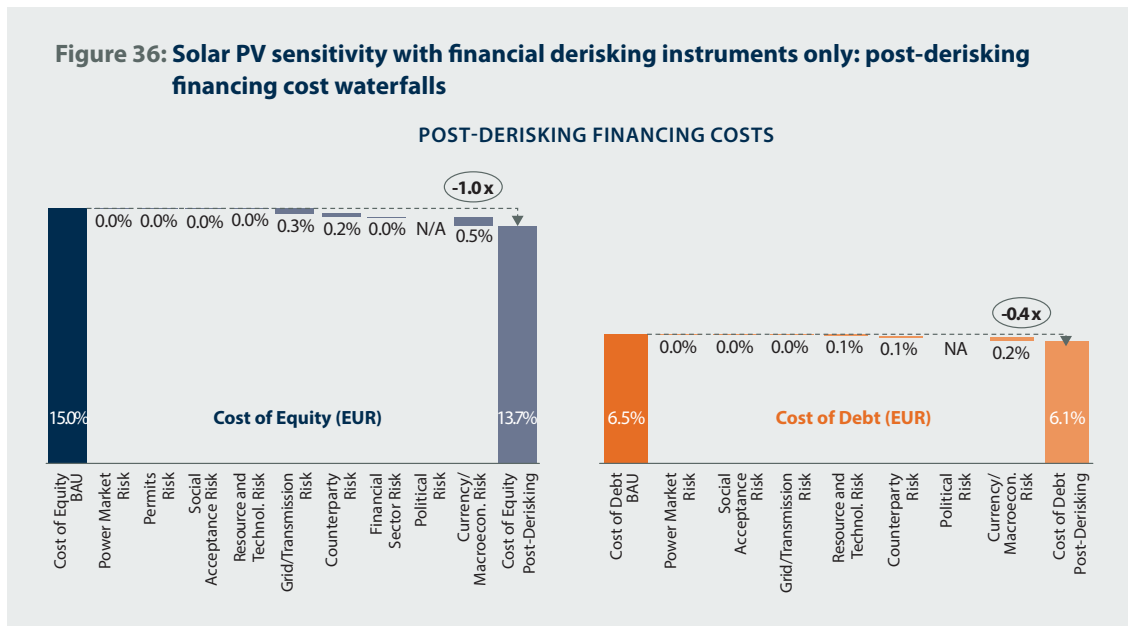
* In the BAU scenario, the full 2030 investment target may not be met.

**Carbon abatement figure components: Business-as-usual, policy derisking instruments EUR 0.06, financial derisking instruments EUR 0.00, price premium EUR 50.42. Post-derisking, EUR 0.35, EUR 0.00 and EUR 43.09 respectively.

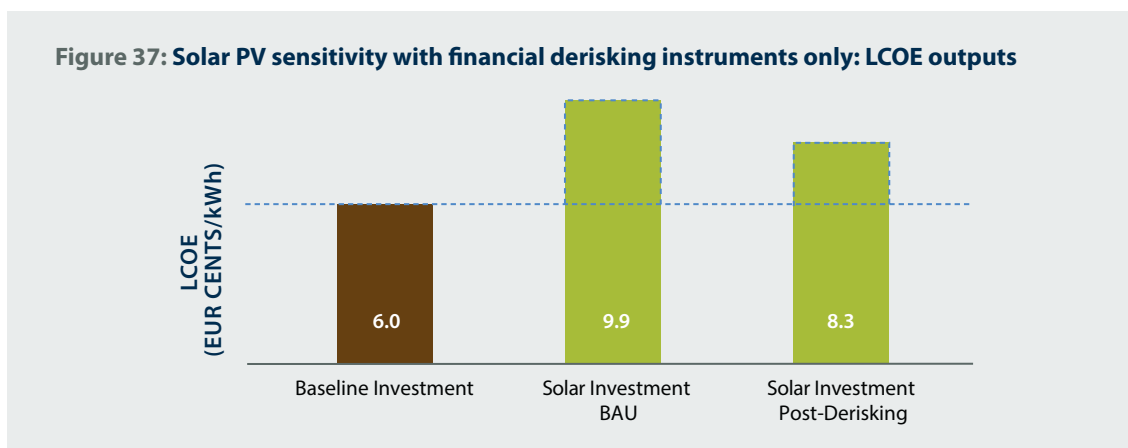
2.5 SENSITIVITY TO FINANCIAL DERISKING INSTRUMENTS ONLY

This sensitivity provides an indication of the impacts of an instrument package focusing solely on financial derisking measures:

- The model's base case includes both policy derisking (EUR 4.4 million) and financial derisking instruments (EUR 140.6 million).
- This sensitivity uses only financial derisking instruments (EUR 140.6 million). The list of financial derisking instruments is presented in Table 8 of the full report.

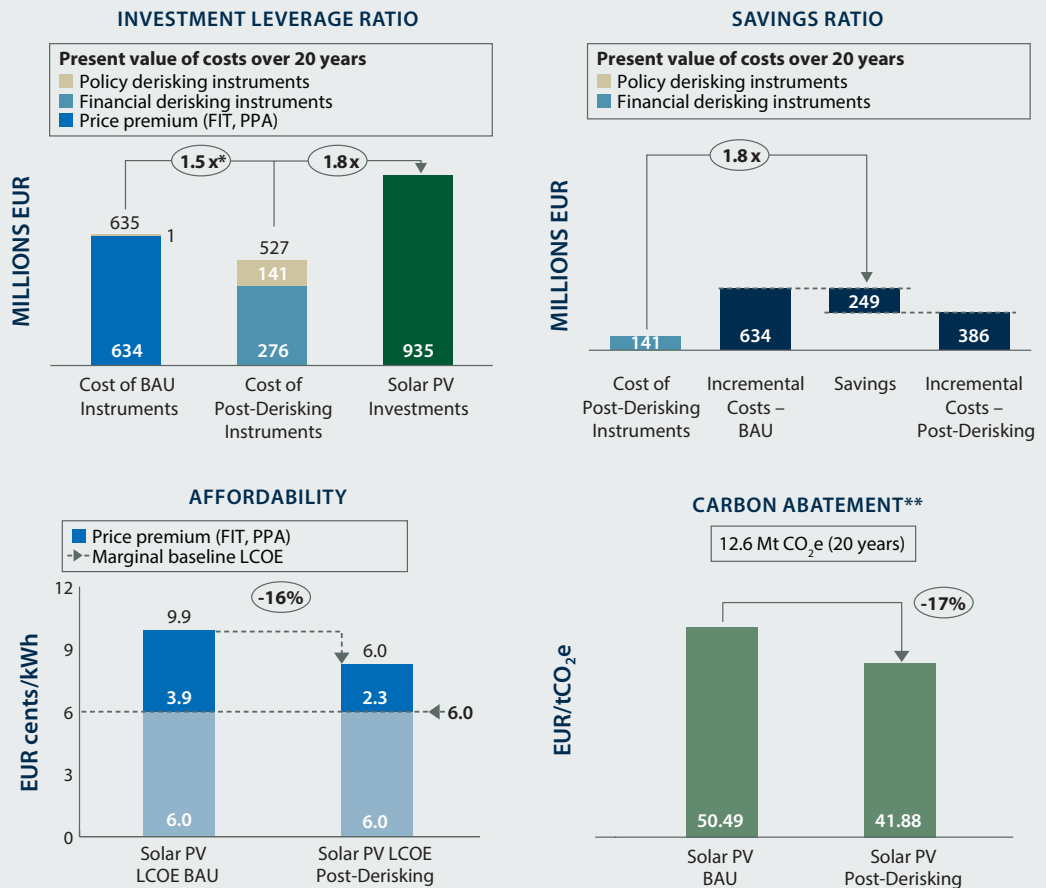


Source: interviews with wind energy and solar PV investors and developers; modelling; see Annex C for details of assumptions and methodology. Note: the impacts shown are average impacts over the 2014-2030 modelling period, assuming linear timing effects.



Source: modelling; see Table 8 and Annex A in the full report for details of assumptions and methodology.

Figure 38: Solar PV sensitivity with financial derisking instruments only: performance metric outputs



Source: modelling; see Table 8 and Annex A in the full report for details of assumptions and methodology.

* In the BAU scenario, the full 2030 investment target may not be met.

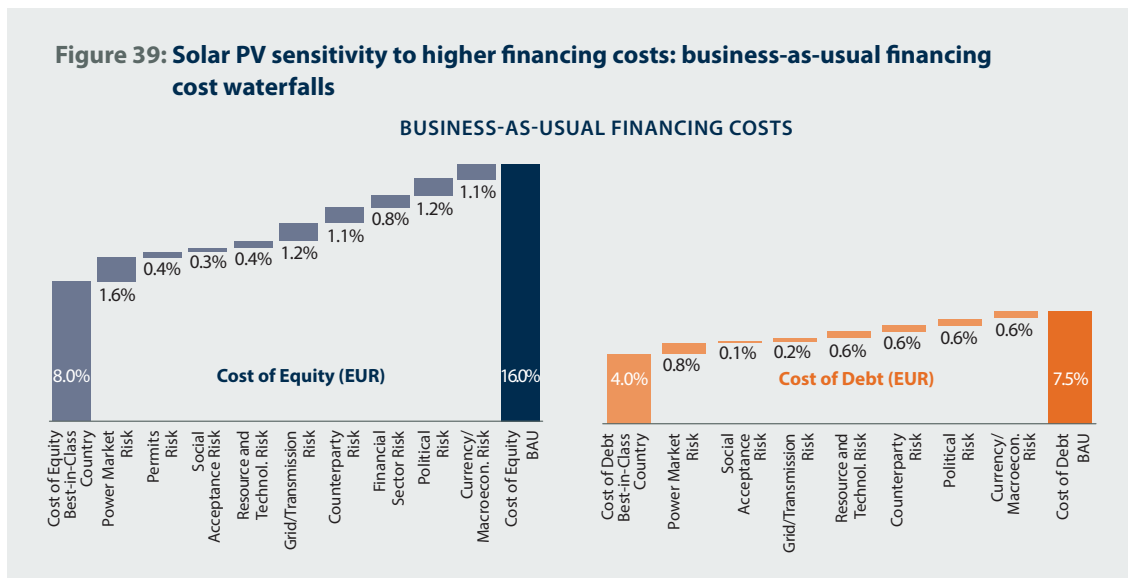
**Carbon abatement figure components: Business-as-usual, policy derisking instruments EUR 0.06, financial derisking instruments EUR 0.00, price premium EUR 50.42. Post-derisking, EUR 0.00, EUR 11.22 and EUR 30.66 respectively.

2.6 SENSITIVITY TO FINANCING COSTS

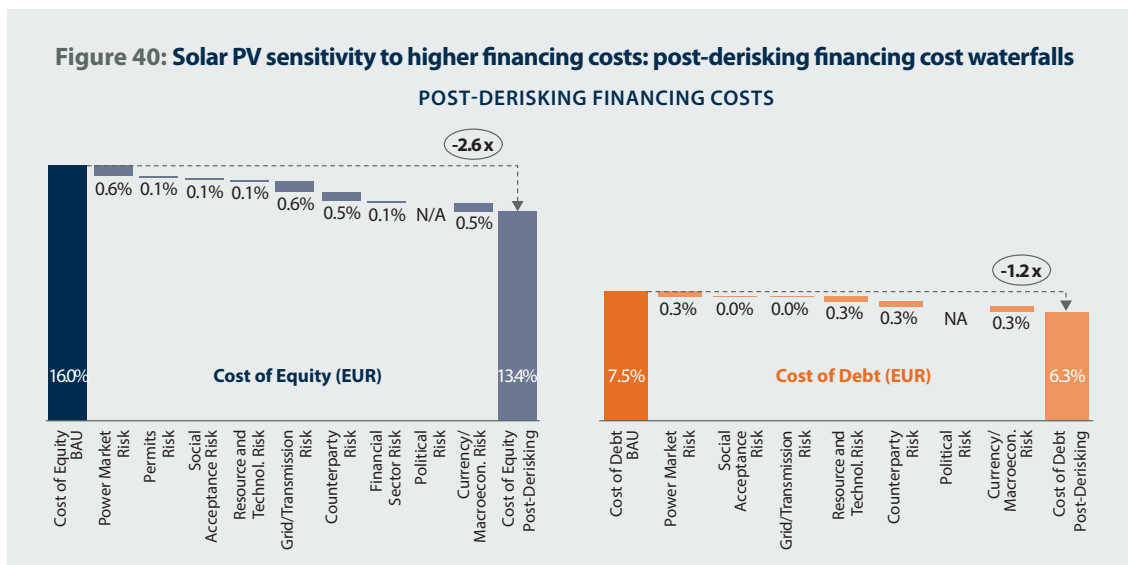
This sensitivity provides an indication of the impacts of higher or lower financing costs.

- The model's base case assumes a 15.0% cost of equity (EUR) and a 6.5% cost of debt (EUR) in Tunisia.
- This sensitivity looks at two scenarios:
 - A scenario in which the financing costs are increased by 1% (100 basis points). The cost of equity is 16.0% (EUR) and the cost of debt is 7.5% (EUR).
 - A scenario in which the financing costs are reduced by 1% (100 basis points). The cost of equity is 14.0% (EUR) and the cost of debt is 5.5% (EUR).

2.6.1 Sensitivity to +1% Financing Costs

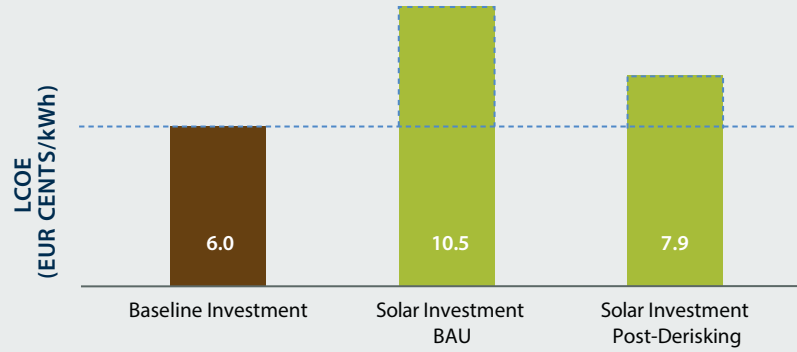


Source: interviews with wind energy and solar PV investors and developers; modelling; best-in-class country is assumed to be Germany; see Annex C for details of assumptions and methodology



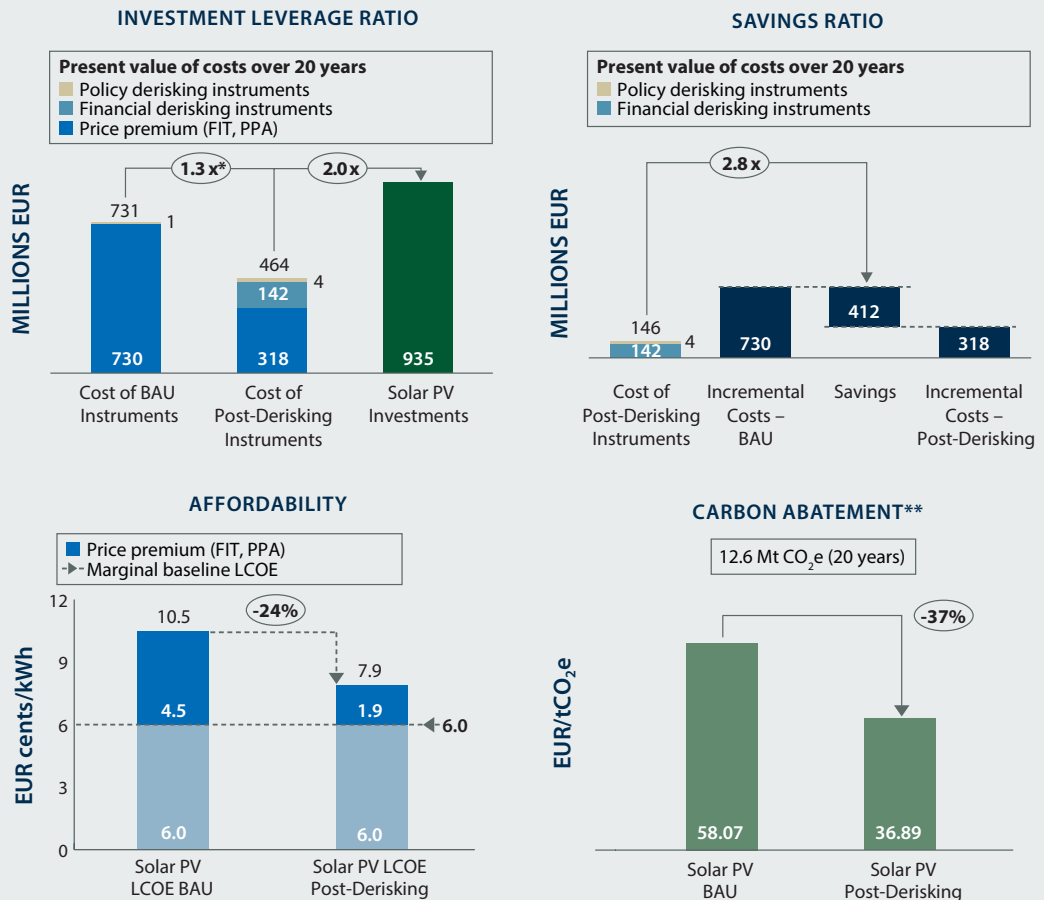
Source: interviews with wind energy and solar PV investors and developers; modelling; see Annex C for details of assumptions and methodology. Note: the impacts shown are average impacts over the 2014-2030 modelling period, assuming linear timing effects.

Figure 41: Solar PV sensitivity to higher financing costs: LCOE outputs



Source: modelling; see Table 8 and Annex A in the full report for details of assumptions and methodology.

Figure 42: Solar PV sensitivity to higher financing costs: performance metric outputs

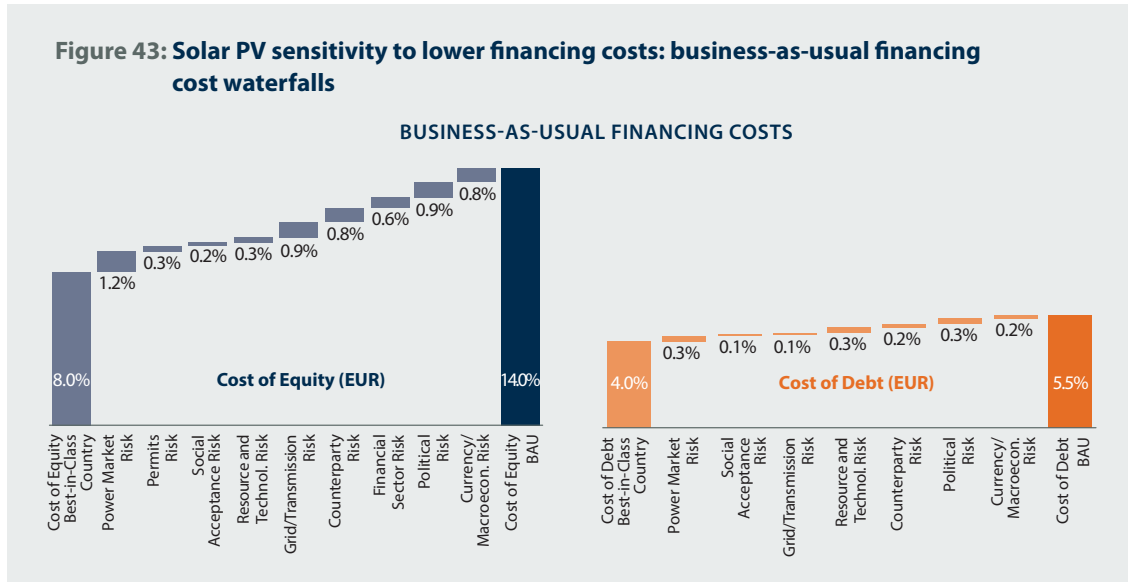


Source: modelling; see Table 8 and Annex A in the full report for details of assumptions and methodology.

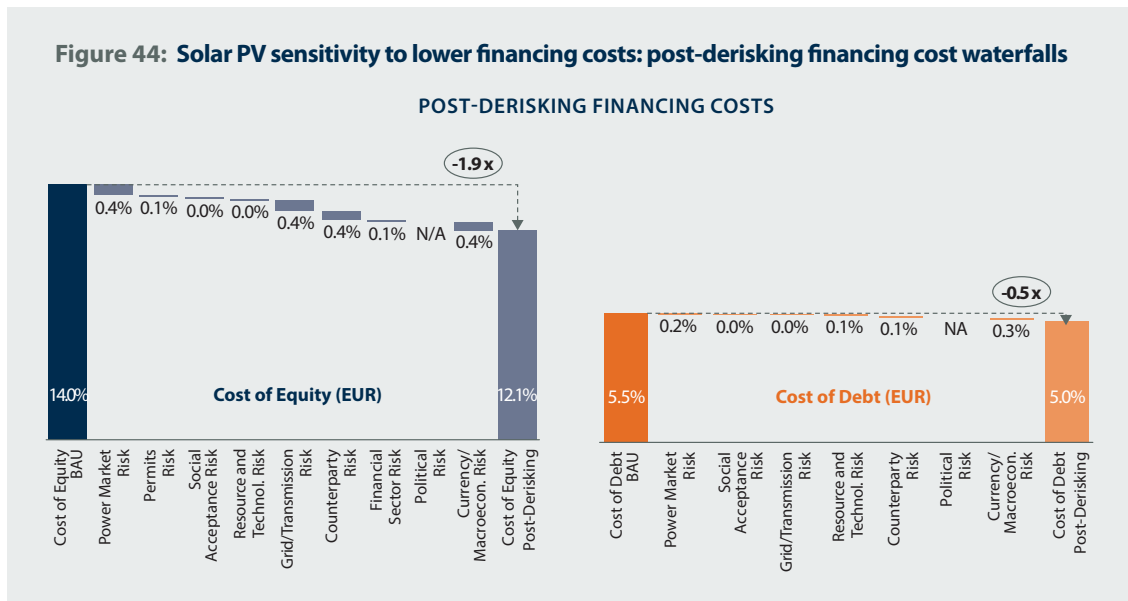
* In the BAU scenario, the full 2030 investment target may not be met.

**Carbon abatement figure components: Business-as-usual, policy derisking instruments EUR 0.06, financial derisking instruments EUR 0.00, price premium EUR 58.01. Post-derisking, EUR 0.35, EUR 11.29 and EUR 25.25 respectively.

2.6.2 Sensitivity to -1% Financing Costs

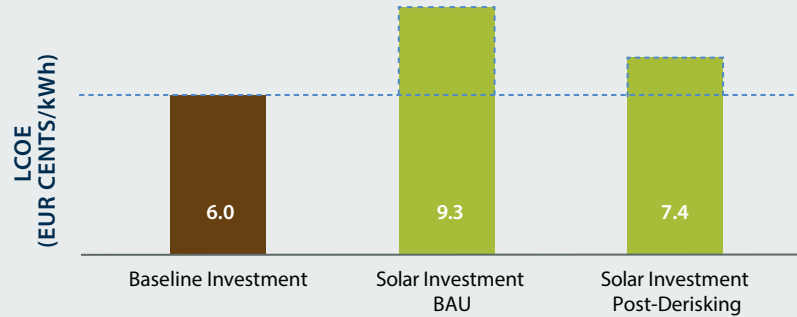


Source: interviews with wind energy and solar PV investors and developers; modelling; best-in-class country is assumed to be Germany; see Annex C for details of assumptions and methodology.



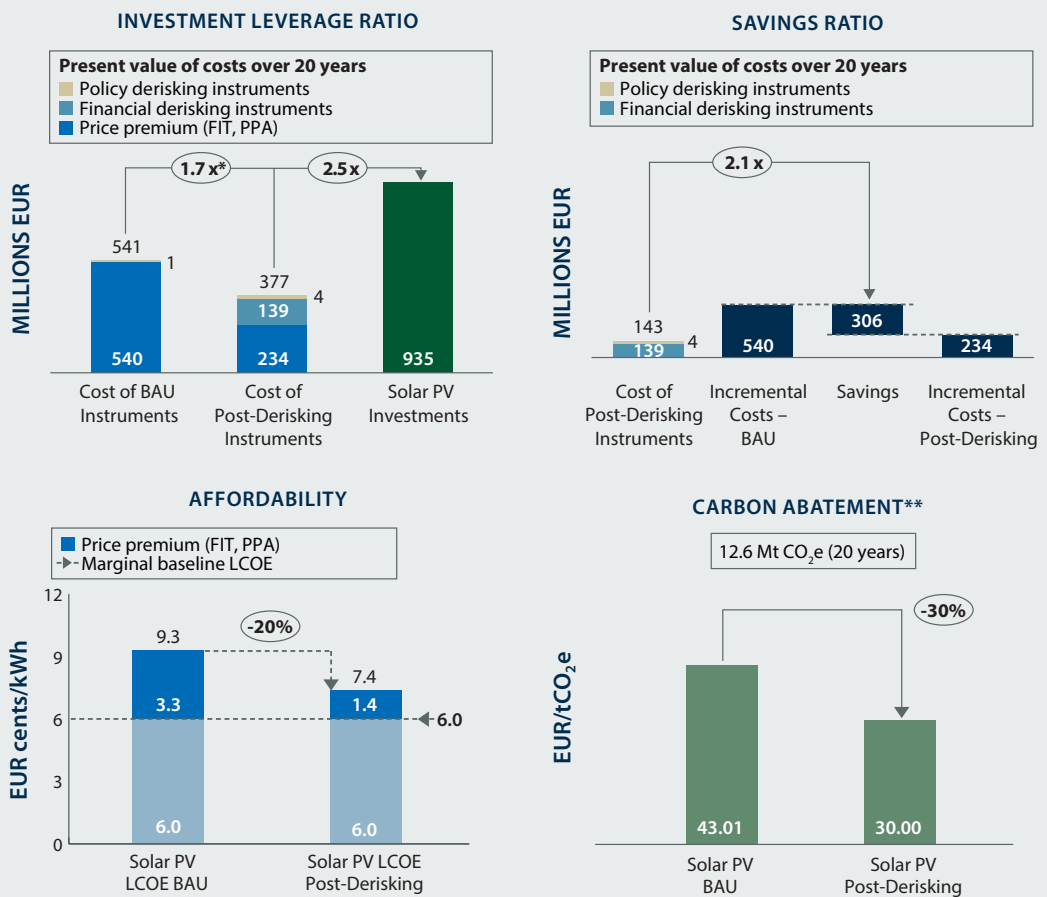
Source: interviews with wind energy and solar PV investors and developers; modelling; see Annex C for details of assumptions and methodology. Note: the impacts shown are average impacts over the 2014-2030 modelling period, assuming linear timing effects.

Figure 45: Solar PV sensitivity to lower financing costs: LCOE outputs



Source: modelling; see Table 8 and Annex A in the full report for details of assumptions and methodology.

Figure 46: Solar PV sensitivity to lower financing costs: performance metric outputs



Source: modelling; see Table 8 and Annex A in the full report for details of assumptions and methodology.

* In the BAU scenario, the full 2030 investment target may not be met.

** Carbon abatement figure components: Business-as-usual, policy derisking instruments EUR 0.06, financial derisking instruments EUR 0.00, price premium EUR 0.06. Post-derisking, EUR 0.35, EUR 11.06 and EUR 18.60 respectively.



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