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TUNISIA:
Derisking Renewable Energy Investment

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

Full Report

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A N M E

The National Agency for Energy Conservation (ANME) of Tunisia is a public institution under the supervision of the Ministry of Industry. It was established in 1985 to ensure the implementation of a national policy in the field of energy management, including the promotion of energy efficiency and renewable energy. www.anme.nat.tn

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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.

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This full report is accompanied by two further documents:

- An **Executive Summary**-only version
- A **Sensitivity Analyses document**. This sets out the full results of the modelling sensitivity analyses of wind energy and solar PV

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Acronyms

ANME	National Agency for Energy Conservation of Tunisia (Agence Nationale pour la Maîtrise de l'Energie)
AFD	Agence Française de Développement
BAU	Business as usual
BOO	Build-Own-Operate
CCGT	Combined Cycle Gas Turbine
CDM	Clean Development Mechanism
CSP	Concentrated Solar Power
DREI	Derisking Renewable Energy Investment
ECN	Energy Research Centre of the Netherlands
EPC	Engineering, Procurement and Construction
EUR	Euro
FiT	Feed-in Tariff
GDP	Gross Domestic Product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GEF	Global Environment Facility
IEA	International Energy Agency
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
kW	Kilowatt
kWh	Kilowatt-hour
LCOE	Levelised Cost of Electricity
MRV	Monitoring, Reporting and Verification
MW	Megawatt
MWh	Megawatt-hour
NA	Not Applicable/Available
NAMA	Nationally Appropriate Mitigation Action
NIMBY	Not In My Back Yard
NREL	National Renewable Energy Laboratory (US)
O&M	Operations and Maintenance

PDD	CDM Project Design Document
PPA	Power Purchase Agreement
PRI	Political Risk Insurance
PV	Photovoltaic
RCREEE	Regional Centre for Renewable Energy and Energy Efficiency
STEG	Tunisia National Electricity and Gas Utility (Societé Tunisienne de l'Electricité et du Gaz)
TSP	Tunisian Solar Plan
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
VAT	Value-Added Tax

Foreword

Foreword

Hamdi Harrouch

Adriana Dinu

The Tunisian Solar Plan, originally formulated in 2012 and now updated in 2015, is Tunisia's official long-term plan for renewable energy. The plan sets out Tunisia's ambition to harness its renewable energy resources in order to advance Tunisia's objectives in sustainable development. It includes specific 2030 targets for investment in wind energy, solar photovoltaic and concentrated solar power.

The opportunity for renewable energy in Tunisia is particularly promising. Tunisia has abundant renewable energy resources, particularly wind and solar. The cost of renewable energy technologies – for example, solar panels and wind turbines – has been steadily falling, changing the economic equation and making renewable energy more competitive than ever. In September 2014, a new law on renewable energy was passed in the Tunisian National Assembly, establishing new policy mechanisms to attract investment.

As part of its activities, the National Agency for Energy Conservation (ANME) is planning to submit a Nationally Appropriate Mitigation Action (NAMA) under the UNFCCC to support the Tunisian Solar Plan. UNDP, with support from the Global Environment Facility, is providing assistance to ANME to develop this NAMA.

This report presents the results of analysis, using an innovative new methodology, *Derisking Renewable Energy Investment*, of possible government interventions to create an investment environment to meet the 2030 targets in the Tunisian Solar Plan. The results provide quantitative data on the cost effectiveness of these government measures. The aim of this report is to assist in the selection of the government interventions which can be included in the NAMA.

This is the first time the *Derisking Renewable Energy Investment* methodology has been applied in the context of a NAMA. While this report's results are specific to Tunisia, the methodology and broader findings of this report have considerable relevance for other countries' NAMAs, as well as for financial mechanisms such as the Global Environment Facility and the nascent Green Climate Fund.

We hope that this report can contribute to the realisation of the Tunisian Solar Plan, and in this way bring clean, secure and affordable renewable energy to the citizens of Tunisia. ANME and UNDP stand ready to collaborate with our partners – in the public sector, private sector and civil society – to make this objective a reality.

Hamdi Harrouch
Director General
National Agency for Energy Conservation

Adriana Dinu
Executive Coordinator, UNDP-GEF
United Nations Development Programme

Key Points for Decision-Makers

In support of the Tunisian Solar Plan, this report sets out the results of a modelling analysis of the cost-effectiveness of public derisking measures[1] to promote private sector investment in large-scale wind energy and solar photovoltaic energy (solar PV) in Tunisia.

The modelling performs a detailed quantification of the financing costs and risk environment for wind energy and solar PV in Tunisia today.

"Power market risk, transmission risk and currency risk are all big contributors to higher financing costs."

- **Financing costs (the cost of equity and the cost of debt) in Tunisia for wind energy and solar PV are high.** For example, it is estimated that the current cost of equity (EUR)[2] for large-scale wind energy and solar PV in Tunisia today is 15.0%, compared with 8.0% in Germany.
- **These higher financing costs in Tunisia reflect a range of investment risks for wind energy and solar PV.** By a clear margin, the risk category that contributes most to higher financing costs is "power market risk". This category concerns power market regulation, such as the need for well-functioning, transparent contractual and pricing mechanisms for the sale of electricity. Other risk categories, including "grid/transmission" risk and "macroeconomic/currency" risk, also make significant contributions to higher financing costs.

For each of wind energy and solar PV, the modelling examines two scenarios to achieve the 2030 Tunisian Solar Plan investment targets: a *business-as-usual* scenario, assuming today's risk environment for investors is maintained; and a *post-derisking* scenario, assuming that public derisking measures are implemented, resulting in an investment environment with reduced risks and lower financing costs.

"Derisking creates savings for Tunisia of EUR 712m (wind energy), and EUR 359m (solar PV), over 20 years."

- For wind energy, public derisking measures catalyse EUR 1.855 billion in private sector investment, and result in wind energy's generation cost falling from EUR 7.5 cents per kWh (*business-as-usual* scenario) to EUR 5.8 cents per kWh (*post-derisking* scenario). **This creates overall economic savings for Tunisia of EUR 712 million over 20 years.** The cost of these derisking measures is estimated at EUR 287 million until 2030 (or EUR 20.5 million per year until 2030[3]). As such, investment in public derisking measures more than pays for itself in terms of economic savings.
- For solar PV, public derisking measures catalyse EUR 935 million in private sector investment, and result in solar PV's generation cost falling from EUR 9.9 cents per kWh (*business-as-usual* scenario) to EUR 7.7 cents per kWh (*post-derisking* scenario). **This creates overall savings for Tunisia of EUR 359 million over 20 years.** The cost of these derisking measures is estimated at EUR 145 million until 2030 (or EUR 8.5 million per year until 2030[3]). Again, investment in public derisking measures more than pays for itself in terms of economic savings.

[1] Public derisking measures can be understood to be domestic government interventions in the form of policies and programmes. These instruments can be non-financial or financial in nature.

[2] Euro-denominated cost of equity.

[3] Annual costs are given in 2014 Euros.

The modelling identifies a comprehensive set of public derisking measures to achieve the 2030 Tunisian Solar Plan's investment targets. These measures include, for example, a well-designed regulatory framework, technical specifications for management of the electricity grid, and public loans for renewable energy developers. A detailed list and costing of the public derisking measures is found in the report.

In comparing these two scenarios, **the results clearly demonstrate how investing in public derisking measures creates significant direct economic savings in achieving the Tunisian Solar Plan.** Instead of paying for investment in wind energy and solar PV at higher generation costs, public derisking measures should be prioritised, thereby resulting in investment at lower generation costs and more affordable electricity for Tunisian citizens.

The development of the Tunisian Solar Plan as a Nationally Appropriate Mitigation Action (NAMA) will entail further development of this analysis of public derisking measures and will serve to itemise their costs. The NAMA will also identify the sources of funding for the public derisking measures, with the opportunity to seek international support for these costs.

"Public derisking measures should be prioritised, resulting in more affordable electricity for Tunisian citizens."

Executive Summary

Executive Summary

Introduction

The analysis set out in this report forms part of UNDP's support to the Government of Tunisia in the development of a Nationally Appropriate Mitigation Action (NAMA) for the Tunisian Solar Plan (TSP). UNDP is providing this support under a Global Environment Facility ("GEF")-financed project entitled "NAMA Support to the Tunisian Solar Plan" (the "NAMA TSP Project"). The project's national implementing partner is the Tunisian National Agency for Energy Conservation (Agence Nationale pour la Maîtrise de l'Energie, ANME). The NAMA TSP Project will be implemented between 2015-2019.

The Tunisian Solar Plan, originally formulated in 2012 and revised in 2015, is Tunisia's official long-term plan for attracting renewable energy investment in the electricity sector. The TSP seeks to achieve a renewable energy penetration target of 30% of the electricity generation mix by 2030.[4] Recognising the scale of the investment required by 2030, the TSP envisages that 80% of the required financing will come from the private sector.

"The TSP envisages that 80% of the required financing will come from the private sector."

Tunisia is also undertaking voluntary measures to reduce its greenhouse gas emissions in the form of NAMAs submitted under the United Nations Framework Convention on Climate Change (UNFCCC). While there is no formal definition of the information to be included in a NAMA, Box 1 below sets out the likely components of a NAMA in the power sector.

The NAMA TSP Project aims to assist the Government of Tunisia in drawing together these parallel strands of work, on the TSP and NAMAs, to develop the TSP itself as a NAMA and thereby create an enabled environment to attract the needed investment and to reduce greenhouse gas emissions in a transparent and verifiable manner.

Box 1: Typical components of a power sector NAMA

A practical understanding of the core components of a typical NAMA in the power sector is now emerging. These are likely to include:

- A **voluntary long-term, time-bound investment** target for low-carbon activities in the power sector. A breakdown of the target will be provided by technology (installed capacity, target years).
- The identification and implementation of a **package of public instruments** to create an enabled environment to attract this targeted investment. The investment will come from a mix of public and private sources, with the majority of investment typically coming from the private sector.
- A breakdown of the **anticipated costs and incremental costs** to achieve the NAMA's investment target, differentiated between financing sources: public and private, domestic and international, as well as market mechanisms (e.g. carbon markets).
- An assessment of the anticipated **socio-economic and environmental co-benefits** that will arise from the targeted investment, including economic growth, job creation and sustainable development benefits.
- An **MRV framework**, with appropriate indicators, to measure, report and verify the emission reductions that will be generated by the investment in low-carbon activities under the NAMA.

[4] The TSP's 2030 targets in terms of total installed capacity are 1,755 MW (wind energy), 1,510 MW (solar PV) and 460 MW (CSP) (ANME, 2012).

The Derisking Renewable Energy Investment Methodology

In 2013, UNDP issued the Derisking Renewable Energy Investment report (the "DREI report") (Waissbein *et al.*, 2013). The DREI report introduced an innovative methodology (the "DREI methodology"), with an accompanying financial tool in Microsoft Excel, to quantitatively compare the cost-effectiveness of different public instruments in promoting renewable energy investment. The analysis of Tunisia set out in this report is based on the DREI methodology.

A key focus of the DREI methodology is on financing costs for renewable energy. While technology costs for renewable energy have fallen dramatically in recent years,[5] private sector investors in renewable energy in developing countries still face high financing costs (both for equity and debt). These high financing costs reflect a range of technical, regulatory, financial and informational barriers and their associated investment risks. Investors in early-stage renewable energy markets, such as those of many developing countries, require a high rate of return to compensate for these risks.[6]

In seeking to create an enabled environment for private sector renewable energy investment, policy-makers typically implement a package of public instruments.[7] From a financial perspective, the public instrument package aims to achieve a risk-return profile for renewable energy that can cost-effectively attract private sector capital. Figure 1 below, from the DREI report, identifies the four key components of a public instrument package that can address this risk-return profile.

The **cornerstone instrument** is the centrepiece of any public instrument package. For large-scale renewable energy, the cornerstone instrument is typically a Feed-in Tariff (FiT) or a tendering process, either of which allows independent power producers (IPPs) to enter into long-term (e.g. 15-20 year) power purchase agreements (PPAs) for the sale of their electricity. The cornerstone instrument can then be complemented by three core types of public instruments:

"Public instruments for renewable energy act in one of three ways, *reducing, transferring* or *compensating* for risk."

- **Instruments that reduce risk,** by addressing the underlying barriers that are the root causes of investment risks. These instruments utilise policy and programmatic interventions. An example might involve a lack of transparency or uncertainty regarding the technical requirements for renewable energy project developers to connect to the grid. The implementation of a transparent and well-formulated grid code can address this barrier, reducing risk. The DREI methodology terms this type of instrument "**policy derisking**".
- **Instruments that transfer risk,** shifting risk from the private sector to the public sector. These instruments do not seek to directly address the underlying barrier but, instead, function by transferring investment risks to public actors, such as development banks. These instruments can include public loans and guarantees, political risk insurance and public equity co-investments. For example, the credit-worthiness of a PPA may often be a concern to lenders. In order to address this, a development bank can guarantee the PPA, taking on this risk. The DREI methodology terms this type of instrument "**financial derisking**".

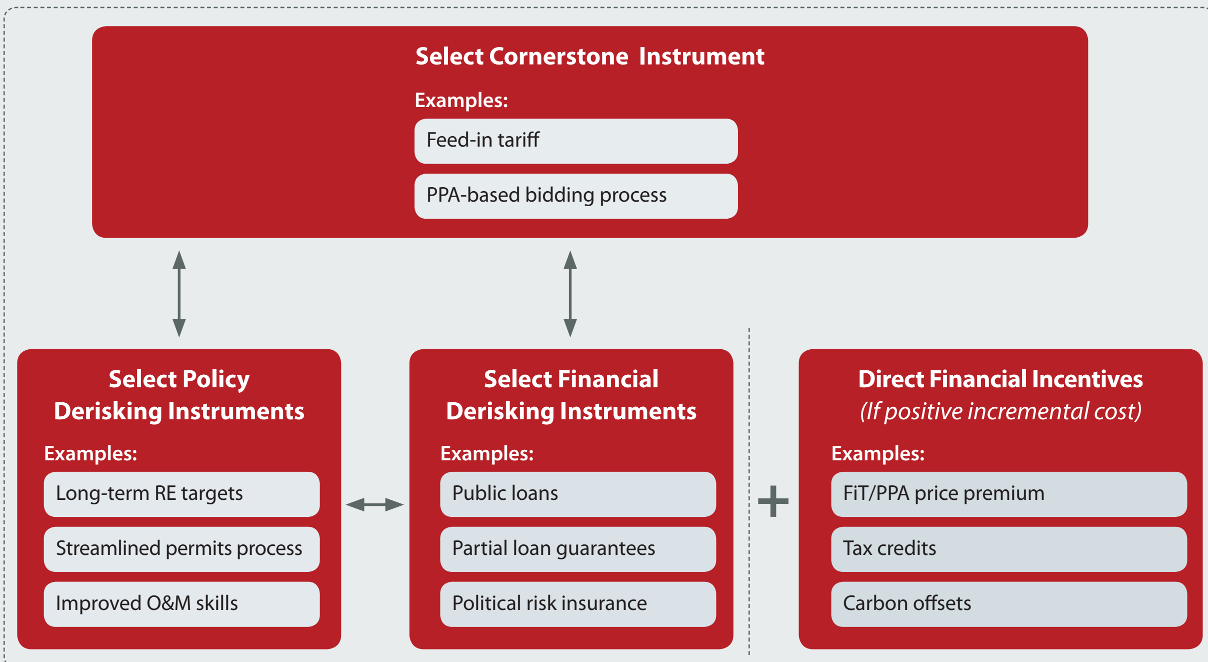
[5] For example, in the case of solar photovoltaic, module costs have experienced a near 98 percent reduction from 1979 to 2012 (IRENA, 2012)

[6] Indeed, as is shown later in this report, interviews with project developers identified higher financing costs for wind energy and solar PV investment in Tunisia in comparison to Germany, a more established market. For example, the cost of equity (EUR) is estimated at 15% in Tunisia today, in comparison to 8% in Germany.

[7] Public instruments can be understood to be domestic government interventions in the form of policies and programmes. These instruments can be non-financial or financial in nature.

- **Instruments that compensate for risk,** providing a financial incentive to investors in the renewable energy project. When risks cannot be reduced or transferred, residual risks and costs can be compensated for. These instruments can take many forms, including price premiums as part of the electricity tariff (either as part of a PPA or FiT), tax breaks and proceeds from the sale of carbon credits. The DREI methodology calls these types of instruments "**direct financial incentives**".

Figure 1: Typical components of a public instrument package for large-scale renewable energy



Source: Derisking Renewable Energy Investment (UNDP, 2013)

Modelling Results

This report, using the DREI methodology, sets out the results of modelling to select public instruments to attract private sector investment to meet the TSP's 2030 targets for large-scale wind energy and solar PV.

Risk Environment

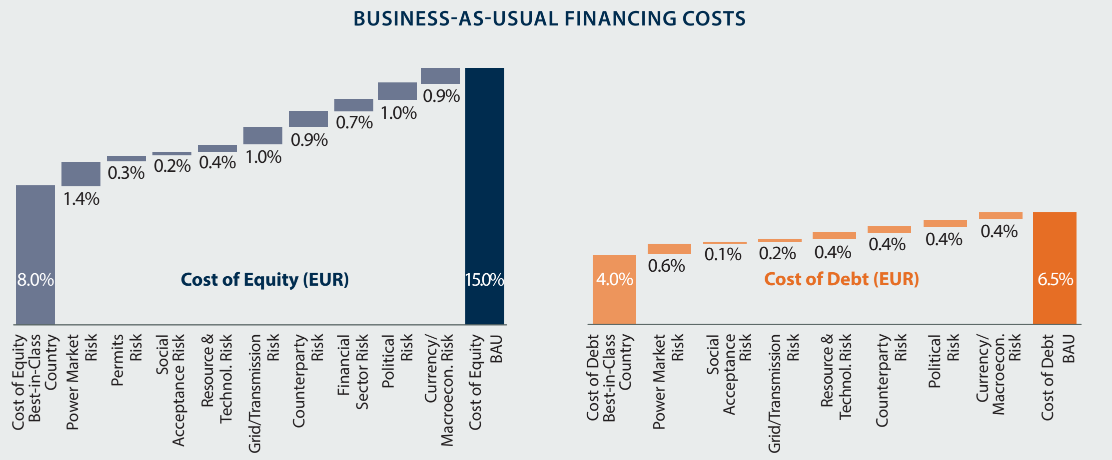
Data on the risk environment were obtained from structured interviews held with 12 domestic and international project developers who are considering, or actively involved, in wind energy and solar PV opportunities in Tunisia.

> “Financing cost waterfalls quantify how different investment risks contribute to higher financing costs in Tunisia.”

The results estimate that financing costs for wind energy and solar PV in Tunisia today are 15.0% for the cost of equity (EUR), and 6.5% for the cost of debt (EUR).[9] These are substantially higher than in the best-in-class country, Germany, which is estimated at 8.0% for the cost of equity (EUR), and 4.0% for the cost of debt (EUR). As is shown in later results, over the long life-time of energy investments, the impact of Tunisia's higher financing costs on the competitiveness of renewable energy is significant.

Figure 2 shows how a range of investment risks currently contribute to these higher financing costs for wind energy and solar PV in Tunisia. The risk category with the largest impact on elevated financing costs is power market risk, which relates to accessing power markets and the price paid for renewable energy. Other risk categories with large impacts include grid/transmission risk, counterparty risk, political risk and macroeconomic/currency risk.

Figure 2: Impact of risk categories on financing costs for wind energy and solar PV investments in Tunisia, business-as-usual scenario[8]



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

[8] The financing cost waterfalls shown here were calculated using one single, common set of assumptions and data for both large-scale wind energy and solar PV. It is recognised that the risk profiles of large-scale wind energy and solar PV can differ, most notably for Resource & Technology risk. However, the results of the interviews with wind energy and solar PV investors made clear that these differences are minimal in the Tunisian context. As such, a single, common approach was adopted in order to bring simplicity to the analysis and to avoid multiple result sets.

[9] Euro- denominated cost of equity and debt.

Public Instrument Selection

The modelling uses 2030 targets, based on the TSP, for both large-scale wind energy (1,404 MW) and solar PV (736 MW).[10] It then models the implementation of a package of public instruments, containing both policy and financial derisking instruments, to promote investment to achieve these targets. The instruments are selected in order to specifically target the risk categories identified in the financing cost waterfalls. A list of these public derisking instruments is shown in Table 1. For wind energy, the costs until 2030 for policy derisking instruments are estimated as being EUR 8.5 million, and for financial derisking instruments EUR 279.0 million. For solar PV, the policy derisking instruments are estimated as costing EUR 4.4 million, and the financial derisking instruments EUR 140.6 million.

"The modelling identifies a comprehensive package of public instruments to target investment risks."

Table 1: The selection of public instruments to achieve the TSP investment targets for wind energy and solar PV.

RISK CATEGORY	POLICY DERISKING INSTRUMENTS	FINANCIAL DERISKING INSTRUMENTS
Power Market Risk	• Long term renewable energy targets • Regulatory framework • FIT/PPA tender (standardised PPA) • Independent regulator	NA
Permits Risk	• Streamlined permitting; one-stop shop; recourse mechanism	NA
Social Acceptance Risk	• Awareness-raising campaigns • Promote/pilot community-based approaches	NA
Resource & Technology Risk	• Resource assessment • Technology support (solar PV)	NA
Grid/Transmission Risk	• Transparent, up-to-date grid code • Grid management/planning	• Take or pay clause in PPA[11]
Counterparty Risk	• Strengthen utility's management	• Government guarantee of PPA
Financial Sector Risk	• Domestic financial sector reform	• Concessional public loans to IPPs
Political Risk	NA	NA
Currency/Macroeconomic Risk	NA	• Partial indexing of PPA tariffs to foreign currencies[12]

Source: modelling. See Annex A for a full description of these instruments. "NA" indicates "Not Applicable".

[10] The model's 2030 investment targets focus on private-sector investment and large-scale renewable energy, adjusting for the portion of the TSP 2030 targets accounted for by public sector investment and small-scale solar PV, respectively.

[11] A "take-or-pay" clause is a clause found in a Power Purchase Agreement (PPA) that essentially allocates risk between parties in the scenario where transmission line failures or curtailment (required by the grid operator) result in the IPP being unable to deliver electricity generated by its renewable energy plant.

[12] Partial indexing involves tariffs in a local-currency denominated PPA being partially indexed to foreign hard currencies, such as EUR or USD. In this way, IPPs are partially protected against currency fluctuations. If a PPA tender process is used, IPPs can be asked to specify the maximum degree of partial indexing they require, thereby minimising the cost to the public sector.

Levelised Costs

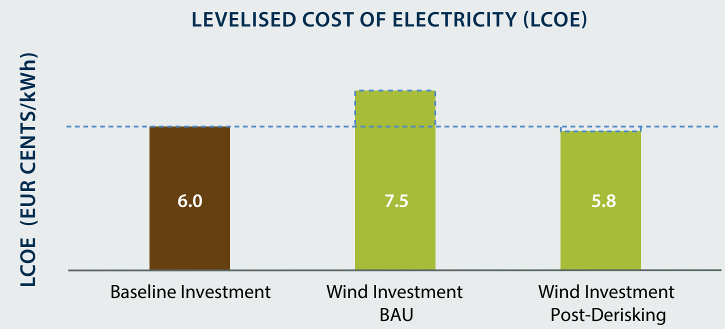
The modelling is performed for two risk environment scenarios; first, a *business-as-usual* scenario, representing the current risk environment (with today's financing costs); and second, a *post-derisking* scenario, after implementing the public instrument packages (resulting in lower financing costs).

The results for generation costs (the Levelised Cost of Electricity, LCOE) are shown in Figures 3 and 4:

- In the *business-as-usual* (BAU) scenario, wind energy and solar PV are more expensive than the baseline. In other words, wind energy and solar PV are more expensive than the baseline technology – combined cycle gas turbines – that Tunisia currently relies on to increase its electricity generation capacity. The baseline generation cost is calculated as being EUR 6.0 cents per kWh. In comparison, wind energy today in Tunisia is estimated at EUR 7.5 cents per kWh, and solar PV at EUR 9.9 cents per kWh. This means that, today, both wind energy and solar PV require a price premium (EUR 1.5 cents per kWh and EUR 3.9 cents per kWh, respectively) over the baseline energy technology.

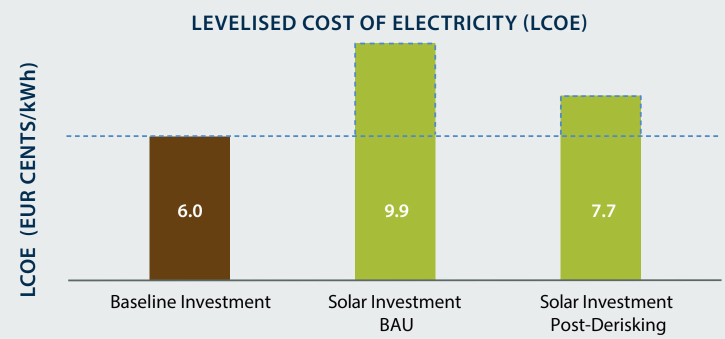
"With derisking measures, wind falls from 7.5 to 5.8 EUR cents per kWh; solar PV falls from 9.9 to 7.7 EUR cents per kWh."

Figure 3: LCOEs for the baseline and wind energy investment in Tunisia



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

Figure 4: LCOEs for the baseline and solar PV investment in Tunisia



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

- In the *post-derisking* scenario, the cost of wind energy falls to EUR 5.8 cents per kWh, and the cost of solar PV falls to EUR 7.7 EUR cents per kWh. As such, following government interventions to derisk the investment environment, and with resulting lower financing costs, wind energy becomes competitive with – in fact cheaper than – the baseline energy technology. Solar PV remains more expensive than the baseline and will still require a price premium (EUR 1.7 cents per kWh) over the baseline.

Evaluation of public instruments' effectiveness

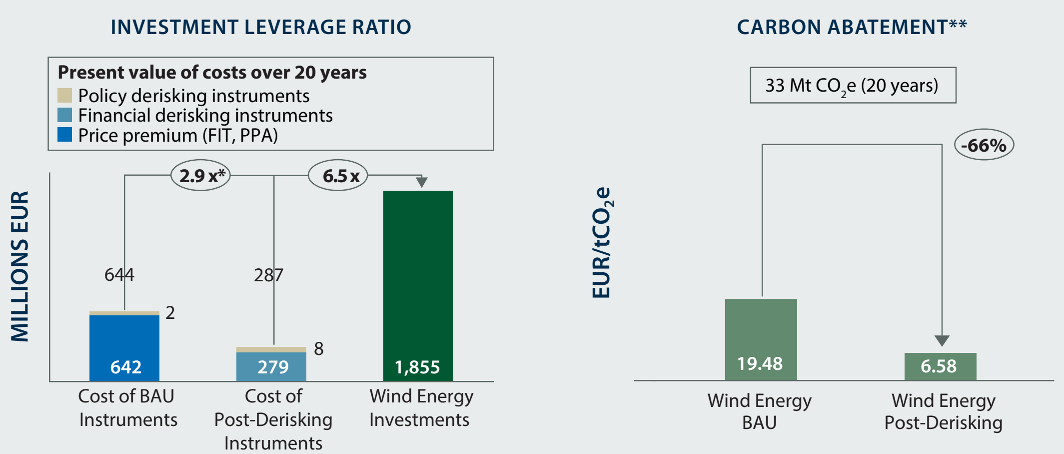
The DREI methodology uses four performance metrics to analyse the impacts of the selected public instrument package to promote investment, each metric taking a different perspective: the ability to catalyse investment (leverage ratio); the economic savings generated for society (savings ratio); the resulting electricity price for end-users (affordability); and the efficiency in mitigating greenhouse gas emissions (carbon abatement).

"Investing in derisking measures totaling EUR 287m, catalyzes EUR 1.8bn in private sector investment in wind energy."

Figure 5 shows the results for the leverage ratio and carbon abatement metrics for wind energy:

- For the leverage ratio, achieving the 2030 target of 1,404 MW in installed wind capacity equates to EUR 1.855 billion in private sector investment. In the business-as-usual scenario, the model estimates that achieving this target will require a direct financial incentive in the form of a price premium over 20 years of EUR 642 million. This results in a leverage ratio (the ratio of the cost of public instruments to investment catalysed) of 2.9x. In the *post-derisking* scenario, the model estimates that this same investment target can

Figure 5: Performance metrics for the selected package of derisking instruments in promoting 1,404 MW of wind energy investment in Tunisia



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

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

** Components of carbon abatement figures: *business-as-usual* scenario: policy derisking instruments EUR 0.05, financial derisking instruments EUR 0.00, price premium EUR 19.43. *Post-derisking* scenario, EUR 0.26, EUR 8.44 and EUR -2.11 respectively.

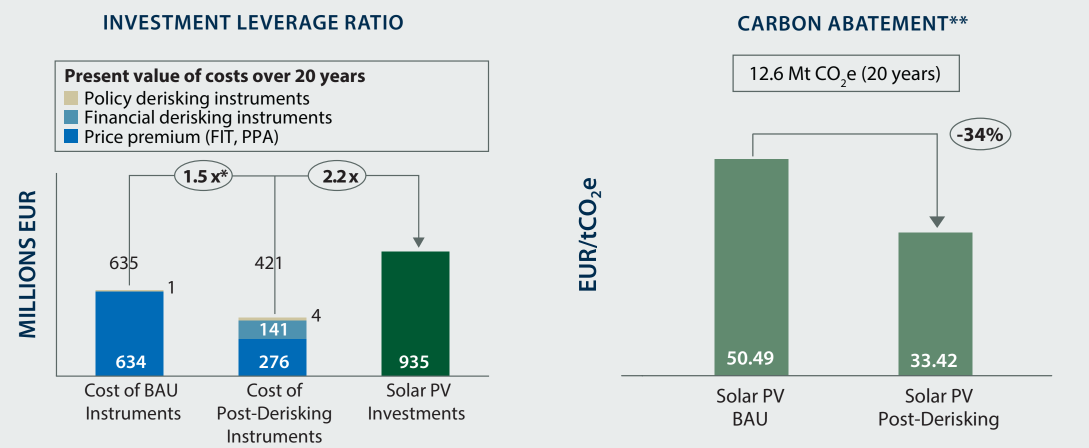
be achieved with a package of derisking instruments valued at EUR 287 million, with no need for any direct financial incentive (price premium). This raises the leverage ratio to 6.5x, indicating a higher efficiency in terms of the costs of public instruments.

- For carbon abatement, achieving the 2030 target of 1,404 MW in wind energy is estimated to result in a total reduction of 33 million tonnes of CO_2 over the lifetime of the wind plants. In the business-as-usual scenario, the abatement cost of the investment in wind energy is EUR 19.43 per tonne of CO_2e. Or, in other words, the cost of public instruments – in this case a direct financial incentive – equates to EUR 19.43 for every tonne of CO_2e reduced by the investment in wind energy. In the *post-derisking* scenario, this cost falls to EUR 6.58 per tonne of CO_2e. This performance metric is helpful in terms of understanding a carbon price that is necessary to promote investment, and in comparing the relative costs of different low-carbon options.

As such, both the leverage ratio and carbon abatement metrics from the modelling on wind energy show improved cost-effectiveness from government measures to derisk the investment environment.

Figure 6 shows selected results for solar PV in Tunisia, this time with the 2030 target of 736 MW of large-scale solar PV private sector investment. As with wind energy, the results demonstrate the beneficial impact of derisking. In this case, however, the LCOE of solar PV remains above the baseline cost, even after derisking.

Figure 6: Performance metrics for the selected package of derisking instruments in promoting 736 MW of solar PV investment in Tunisia



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

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

** Components of carbon abatement figures: *business-as-usual* scenario: policy derisking instruments EUR 0.06, financial derisking instruments EUR 0.00, price premium EUR 50.42. *Post-derisking* scenario, EUR 0.35, EUR 11.17 and EUR 21.90 respectively.

Sensitivities

Sensitivity analysis of the modelling identifies the inputs for: (i) investment costs, (ii) capacity factors, (iii) gas costs and (iv) financing costs (cost of debt, cost of equity) as all being key assumptions which can impact the results.

The assumptions for investment costs (i.e., the cost of hardware, such as wind turbines and solar panels) have particular potential for improving the overall competitiveness of wind energy and solar PV in Tunisia. Globally, the costs of renewable energy hardware have shown consistent reductions over time. The model's base case uses data for current (2014) investment costs for this assumption. Should investment costs continue to fall, the sensitivity analysis examines a scenario which uses lower (2022) investment costs.[13] The results of this sensitivity analysis are shown in Table 2 below, where significant reductions can be seen for both wind energy and solar PV generation costs. For example, wind energy generation cost in the *post-derisking* scenario falls from EUR 5.8 cents per kWh to EUR 5.2 cents per kWh.

Table 2: Sensitivity analysis of wind energy and solar PV investment costs in Tunisia. (All units EUR cents per kWh)

TECHNOLOGY	TYPE OF SENSITIVITY	A SSUMPTION	BAU LCOE	POST-DERISKING LCOE
Wind	Base Case	Assuming 2014 costs: EUR 1.241 million/MW	7.5 cents	5.8 cents
	Lower Investment Costs	Assuming 2022 costs: EUR 1.117 million/MW	6.8 cents	5.2 cents
Solar PV	Base Case	Assuming 2014 costs: EUR 1.190 million/MW	9.9 cents	7.7 cents
	Lower Investment Costs	Assuming 2022 costs: EUR 1.010 million/MW	8.5 cents	6.6 cents

Source: modelling; see Tables 7 and 8, Annex A and the Sensitivity Analyses document for details of assumptions and methodology.

"Sensitivity analyses modelling continued falls in investment costs result in significant reductions in generation costs."

[13] The modelling period is 2014-2030. The year 2022 is selected as it reflects the mid-point of this period.

Conclusions

Implications for promoting renewable energy in Tunisia

The results confirm that financing costs for wind energy and solar PV in Tunisia are currently high, particularly in comparison to countries with more favourable investment environments. The cost of equity for wind energy and solar PV in Tunisia today is estimated at 15.0% (EUR), and the cost of debt at 6.5% (EUR).[14] The modelling identifies nine different risk categories that contribute to these higher financing costs in Tunisia. Power market risk – which concerns risks relating to regulations and pricing mechanisms for renewable energy – is identified as the most significant risk category, contributing an estimated 1.4% to the cost of equity. Four other categories – grid/transmission risk, counterparty risk, political risk and currency/macroeconomic risk – are also large contributors to high financing costs, increasing the cost of equity by approximately 1.0% each.

"A key conclusion is that investing in derisking measures is a cost-effective approach for achieving the investment objectives of the Tunisian Solar Plan."

A key conclusion from the modelling is that investing in derisking measures to target these investment risks is a cost-effective approach for achieving the investment objectives of the Tunisian Solar Plan. The derisking measures that are modelled bring down the generation cost of wind energy from EUR 7.5 cents per kWh to EUR 5.8 cents per kWh, and solar PV energy from EUR 9.9 cents per kWh to EUR 7.7 cents per kWh. These lower generation costs have important affordability implications for Tunisian end-users. The modelling also demonstrates that investing in derisking measures is good value for money when measured against paying a premium price for wind energy and solar PV.

- For wind energy, in the *business-as-usual* scenario, the modelling estimates that a premium price totalling EUR 642 million will be required over the next 20 years to achieve the TSP target. However, if a total investment of EUR 287 million is made in derisking measures (EUR 20.5 million per year until 2030[15]), wind energy will become cheaper than the baseline energy cost, eradicating the need for a premium price and saving EUR 712 million in generation costs over 20 years.

- For solar PV, in the *business-as-usual* scenario, the modelling estimates that a premium price totalling EUR 634 million will be required over the next 20 years to achieve the TSP target. However, if a total investment of EUR 145 million is made in derisking measures (EUR 8.5 million per year until 2030[16]), solar PV generation costs fall, and the premium price is reduced by EUR 359 million in generation costs over 20 years. The new premium price requirement is EUR 276 million over 20 years.

Overall, the results indicate that all derisking instruments that can be immediately implemented should, if possible, be prioritised before resorting to premium prices to compensate for any residual risks.

[14] Euro-denominated cost of equity and cost of debt.

[15] Annual costs are given in 2014 Euros.

[16] The modelling period is 2014-2030. The year 2022 is selected as it reflects the mid-point of this period.

Applicability of DREI methodology to NAMA design

This report represents the first instance of the DREI methodology being used to assist with the design of a country's NAMA. The results indicate that the DREI methodology appears to be well suited to NAMA design. It provides a structured framework to quantify and itemise the various components of a NAMA, including the costs of investments, the selection and cost of public instruments, and the anticipated greenhouse gas emission reductions.

Following the initial analysis in this report, the DREI methodology will be applied in full under the ANME-implemented, GEF-financed NAMA TSP project as one of the methodological approaches to developing the NAMA TSP.

"The DREI methodology appears well suited to NAMA design, itemising investment costs, public instrument costs, and GHG emission reductions."

Next steps

The results in this report should not be interpreted as a definitive quantitative analysis of wind energy and solar PV in Tunisia but, rather, as one contribution to the larger policy decision-making process. It is hoped that the findings in this report can be compared, contrasted and combined with other analyses.

The modelling team has identified a number of areas of further work for future applications of the DREI methodology in Tunisia, including examining the role of fossil fuel subsidies, additional sensitivity analyses and work on the costs of public instruments.

ANME and UNDP look forward to working with our partners in Tunisia to advance the NAMA design, and to bring the benefits of reliable and affordable renewable energy to the citizens of Tunisia.

1. Introduction

Introduction

1

This report is part of UNDP's support to the Government of Tunisia in the development of a Nationally Appropriate Mitigation Action (NAMA) for the Tunisian Solar Plan (TSP). UNDP is providing this support through a Global Environment Facility (GEF)-financed project entitled "NAMA Support to the Tunisia Solar Plan" (the "NAMA TSP Project"). The national implementing partner of the project is the National Agency for Energy Conservation of Tunisia (Agence Nationale pour la Maîtrise de l'Energie, ANME). The NAMA TSP Project will be implemented between 2015-2019.

The TSP, originally formulated in 2012[17] and revised in 2015, is Tunisia's official long-term plan for attracting renewable energy investment. The TSP seeks to achieve a total renewable energy penetration target of 30% of the electricity generation mix by 2030. The technologies addressed under the TSP are wind, solar photovoltaic (PV) and concentrated solar power (CSP). The 2030 target for wind energy is 15%, or 1,755 MW of installed capacity; the target for solar PV is 10%, or 1,510 MW; and the target for CSP is 5%, or 460 MW. Recognising the large scale of the investment required by 2030, the TSP envisages that 80% of the financing needed to achieve the 2030 targets will come from the private sector.

Tunisia is also undertaking voluntary measures to reduce its greenhouse gas emissions in the form of NAMAs submitted under the United Nations Framework Convention on Climate Change (UNFCCC). While there is no formal definition of the information to be included in a NAMA, Box 2 below sets out the likely components of a NAMA in the power sector.

Box 2: Typical components of a power sector NAMA

There is no formal definition of the information to be included in a NAMA. Nonetheless, a practical understanding of the core components of a typical NAMA in the power sector is now emerging. These are likely to include:

- A **voluntary long-term, time-bound investment** target for low-carbon activities in the power sector. A breakdown of the target will be provided by technology (installed capacity, target years).
- The identification and implementation of a **package of public instruments** to create an enabled environment to attract this targeted investment. The investment will typically come from a mix of public and private sources, with the majority of investment coming from the private sector.
- A breakdown of the **anticipated costs and incremental costs** to achieve the NAMA's investment target, differentiated between financing sources: public and private, domestic and international, as well as market mechanisms (e.g. carbon markets).
- An assessment of the anticipated **socio-economic and environmental co-benefits** that will arise from the targeted investment, including economic growth, job creation and sustainable development benefits.
- An **MRV framework**, with appropriate indicators, to measure, report and verify the emission reductions that will be generated by the investment in low-carbon activities under the NAMA.

[17] Financial support for the 2012 version of the TSP was provided by the Agence Française de Développement (AFD).

The NAMA TSP Project aims to assist the Government of Tunisia in drawing together these parallel strands of work, on the TSP and NAMAs, to develop the TSP itself as a NAMA and thereby create an enabled environment to attract the needed investment and to reduce greenhouse gas emissions in a transparent and verifiable manner.

This report, using the *Derisking Renewable Energy Investment* (DREI) methodology developed by UNDP, sets out the modelling results for selecting public instruments to attract renewable energy investment to meet the TSP's 2030 targets for wind energy and solar PV.[18] This preliminary modelling has been performed during the preparation of the ANME-executed, GEF-financed NAMA TSP Project, with the objective of providing an initial indication of the scope of public measures which a NAMA for the TSP may cover. Following the preliminary modelling, the DREI methodology will be applied in full as part of the NAMA TSP project in 2015-2019.

[18] CSP has been excluded from this preliminary modelling, which has focused on the mature technologies of wind energy and solar PV. It is expected that CSP will be included in the future full application of the DREI methodology during the NAMA design process.

2. Overview of the Derisking Renewable Energy Investment Methodology

Overview of the Derisking Renewable Energy Investment Methodology

2

In 2013, UNDP issued the *Derisking Renewable Energy Investment* report (the "original DREI report") (Waissbein *et al.*, 2013).[19] The report introduced an innovative methodology (the "DREI methodology"), with an accompanying financial tool in Microsoft Excel, to quantitatively compare different public instruments for promoting renewable energy investment. This section provides an overview of the following aspects of the DREI methodology:

- The methodology's focus on financing costs for renewable energy
- The methodology's approach to identifying a public instrument mix
- The methodology's 4-stage framework

For more detailed information on the DREI methodology, please see the original DREI report.

2.1 THE IMPACT OF HIGH FINANCING COSTS ON RENEWABLE ENERGY

A key focus of the DREI methodology is on financing costs for renewable energy. While technology costs for renewable energy have fallen dramatically in recent years,[20] private sector renewable energy investors in developing countries still face high financing costs (both for equity and debt). These high financing costs reflect a range of technical, regulatory, financial and informational barriers and their associated investment risks. Investors in early-stage renewable energy markets, such as those of many developing countries, require a high rate of return to compensate for these risks.

Figure 7, from the original DREI report, illustrates how these high financing costs can impact the competitiveness of renewable energy. The figure shows the results of UNDP modelling to compare the levelised cost of electricity (LCOE) of onshore wind energy and combined-cycle gas in a developed and developing country. The analysis assumes a low financing cost environment for the developed country (cost of equity of 10%; cost of debt of 5%), and a high financing cost environment for the developing country (cost of equity of 18%; cost of debt of 10%). All modelling assumptions (investment costs, operational costs, capacity factors) are kept constant between the developed and developing country – the only assumption that is varied is that relating to financing costs.

In the developed country benefiting from low financing costs, wind power (at USD 6.7 cents per kWh) can be almost cost-competitive with gas (at USD 6.1 cents per kWh). However, in the developing country with higher financing costs, wind power generation (at USD 9.4 cents per kWh) becomes 40 percent more expensive than in a developed country. In contrast, gas (at USD 6.5 cents per kWh) becomes only 6 percent more expensive due to these same higher financing costs. As such, in the developing country, wind power is no longer competitive with gas in this high financing cost environment.

[19] Available for download at www.undp.org/DREI.

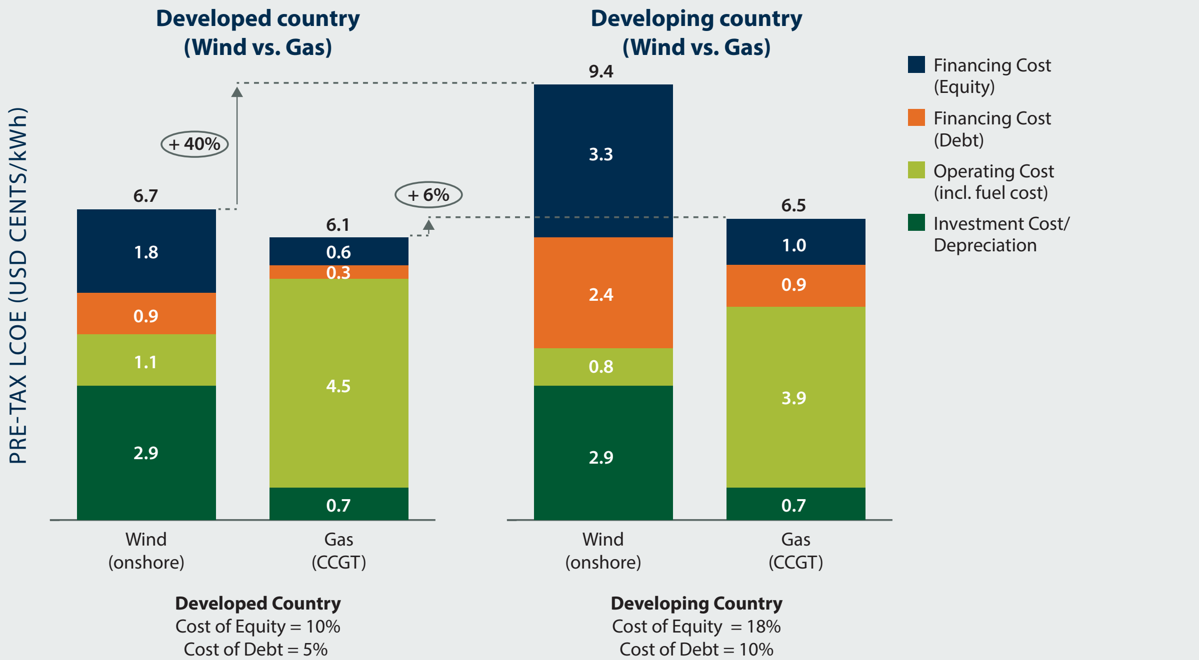
[20] For example, in the case of solar photovoltaic, according to data from Bloomberg New Energy Finance, module costs experienced a 99 percent reduction between 1977 and 2013 (WEC, 2013).

The sensitivity of wind power – and many other forms of renewable energy (Schmidt, 2014) – to financing costs is due to the high upfront capital intensity of renewable energy. Renewable energy's upfront capital intensity is a function of its required initial investment in equipment, for example wind turbines and solar panels. Following this initial investment, renewable energy typically has very low operating costs and does not require any fuel costs. Fossil-fuel based energy generation typically has the reverse profile, with low upfront costs and high operating costs and fuel costs.[21] The end result is that high financing cost environments penalise renewable energy when compared to fossil-fuel based power generation.

The theory of change underlying the DREI methodology is that one of the main challenges for scaling-up renewable energy technologies in developing countries is to lower the financing costs that affect renewables' competitiveness against fossil fuels. As these higher financing costs reflect barriers and associated risks in the investment environment, the key entry point for policy-makers promoting renewable energy is to address these risks and therefore lower overall life-cycle costs.

> "High financing costs in developing countries reflect a range of underling risks. Renewable energy, given its upfront capital intensity, is penalized in high financing cost environments."

Figure 7: Comparing wind energy and gas LCOEs in developed and developing countries



Source: Derisking Renewable Energy Investment (UNDP, 2013)

All assumptions (investment costs, operational costs, capacity factors) except for the financing costs are kept constant between the developed and developing country. See Annex A of the original DREI report for full assumptions. Operating costs appear as a lower contribution to LCOE in developing countries due to discounting effects from higher financing costs.

[21] For example, based on the analysis shown in Figure 7, investment costs account for approximately 80% of the total lifetime technology costs for wind energy but only account for around 15% of such costs in the case of gas. See Annex A of the original DREI report for assumptions.

2.2 IDENTIFYING A PUBLIC INSTRUMENT MIX TO PROMOTE RENEWABLE ENERGY

In seeking to create an enabled investment environment for renewable energy, policy-makers typically implement a package of public instruments. Identifying an appropriate combination of instruments can be highly challenging. Moreover, these public instruments can come at a cost – to industry, to consumers or to the tax-payer.

From a financial perspective, the overall aim for policy-makers in assembling a public instrument package is to achieve a risk-return profile for renewable energy that can cost-effectively attract private sector capital. Figure 8 below, from the original DREI report, identifies the four key components of a public instrument package that can address this risk-return profile.

The **cornerstone instrument** is the centrepiece of any public instrument package. While there are tens, if not hundreds, of public instruments, only a select handful of instruments have shown themselves to be highly effective at transforming markets. For large-scale renewable energy, the cornerstone instrument is typically a Feed-in Tariff (FiT) or a Power Purchase Agreement (PPA) tender process, either of which allows independent power producers (IPPs) to enter into long-term (e.g. 15-20 year) power purchase agreements with grid operators.

The cornerstone instrument can then be complemented by three core types of public instruments:

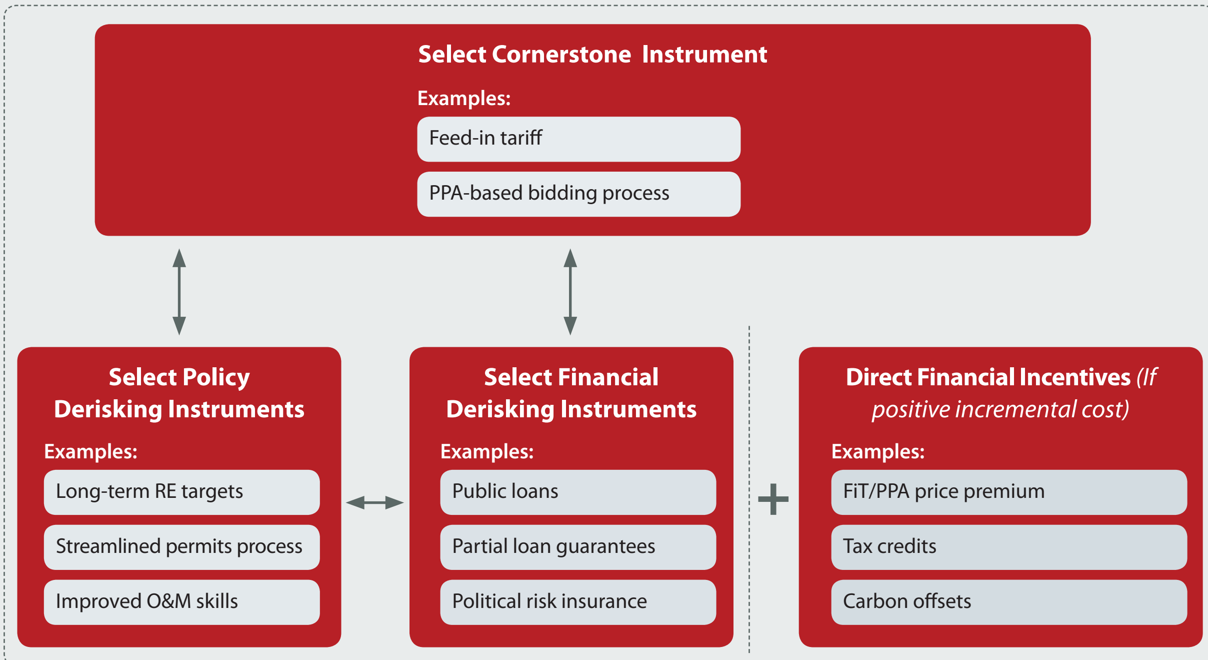
- **Instruments that reduce risk**, by addressing the underlying barriers that are the root causes of investment risks. These instruments utilise policy and programmatic interventions. An example might involve a lack of transparency or uncertainty regarding the technical requirements for renewable energy project developers to connect to the grid. The implementation of a transparent and well-formulated grid code can address this barrier, reducing risk. The DREI methodology terms this type of instrument **"policy derisking"**.

- **Instruments that transfer risk**, shifting risk from the private sector to the public sector. These instruments do not seek to directly address the underlying barrier but, instead, function by transferring investment risks to public actors, such as development banks. These instruments can include public loans and guarantees, political risk insurance and public equity co-investments. For example, the credit-worthiness of a PPA may often be a concern to lenders. A development bank guarantee can provide banks with the security to lend to project developers. The DREI methodology terms this type of instrument **"financial derisking"**.

- **Instruments that compensate for risk**, providing a financial incentive to investors in the renewable energy project. When risks cannot be reduced or transferred, residual risks and costs can be compensated for. These instruments can take many forms, including price premiums (either as part of a PPA or FiT), tax breaks, and proceeds from the sale of carbon credits. The DREI methodology calls these types of instruments **"direct financial incentives"**.

"Public instruments for renewable energy act in one of three ways, *reducing, transferring* or *compensating* for risk."

Figure 8: Typical components of a public instrument package for large-scale renewable energy



Source: Derisking Renewable Energy Investment (UNDP, 2013)

2.3 THE METHODOLOGY'S FOUR STAGE FRAMEWORK

The original DREI report sets out a detailed methodology to support policy decision-making by quantitatively comparing different public instrument portfolios and their impacts.

Selecting public instruments for renewable energy is highly dependent on national circumstances. Each country has its own particular renewable resources, objectives and constraints. Therefore, the methodology is designed to be applied flexibly and to be tailored to a specific renewable energy technology and national context. As illustrated in Figure 9, the methodology is organised into a framework with four stages, each of which is, in turn, divided into two steps.

- **Stage 1: Risk Environment** identifies the set of investment barriers and associated risks relevant to the renewable energy technology, and analyses how the existence of investment risks can increase financing costs.

- **Stage 2: Public Instruments** selects a mix of public derisking instruments to address the investor risks and quantifies how they, in turn, can reduce financing costs. This stage also determines the cost of the selected public derisking instruments.

- **Stage 3: Levelised Cost** determines the degree to which the reduced financing costs impact the renewable energy life-cycle cost (LCOE). This is then compared against the current baseline generation costs in the country.
- **Stage 4: Evaluation** assesses the selected public derisking instrument mix using four performance metrics, as well as through the use of sensitivity analyses. The four metrics are: (i) investment leverage ratio, (ii) savings leverage ratio, (iii) end-user affordability and (iv) carbon abatement.

The intent of the methodology is not to provide one predominant numerical result but is, instead, to facilitate a structured, transparent process whereby key inputs and assumptions are made explicit, so that they can contribute to and inform the design process.

"The methodology facilitates a structured, transparent process whereby key inputs and assumptions are made explicit."

Figure 9: Overview of the DREI methodology for selecting public instruments to promote renewable energy investment

	Step 1		Step 2
Stage 1: Risk Environment	• Determine a multi-stakeholder barrier and risk table for the renewable energy investment	→	• Quantify the impact of risk categories on increased financing costs
Stage 2: Public Instruments	• Select one or more public derisking instrument(s) to mitigate the identified risk categories	→	• Quantify the impact of the public derisking instrument(s) to reduce financing costs • Quantify the public costs of the public derisking instrument(s)
Stage 3: Levelised Cost	• Calculate the levelised cost of electricity (LCOE) for the baseline energy generation mix in the particular country	→	• Quantify the LCOE for renewable energy investment in the (i) pre-derisking and (ii) *post-derisking scenarios* • Calculate the incremental cost (or savings) by comparing these scenarios vs. the baseline
Stage 4: Evaluation	• Analyse the selected public instrument(s) in terms of four key performance metrics	→	• Perform sensitivity analyses on key inputs and assumptions

Source: Derisking Renewable Energy Investment (UNDP, 2013)

3. Current Status of Wind Energy and Solar PV in Tunisia

Current Status of Wind Energy and Solar PV in Tunisia

3

This section provides a brief overview of the current context, status and objectives for wind energy and solar PV in Tunisia.

Tunisia General Country Data[22]	
Population 2011:	10.7m
Land Area:	162,155 sq. km
GDP 2013 (USD):	$46.6 billion
GDP/capita (USD, PPP) 2013:	$9,175
Sovereign rating 2014:	Non-Investment grade, Ba3 (Moody's)
UNDP HDI 2013:	0.721 (90th of 187)

2030 Targets for Wind Energy and Solar PV

The Tunisian Solar Plan (TSP) identifies 2030 investment targets for wind energy and solar PV totalling 1,755 MW and 1,510 MW, respectively. Wind energy and solar PV offer the potential to meet Tunisia's rapidly growing energy demand. A greater share of renewable energy can also help in reducing the government's subsidies for conventional fossil-based fuel generation. Looking further ahead, electricity generated from wind and solar could also be a significant export industry for Tunisia.

The modelling presented in this report uses adjusted 2030 TSP targets of 1,404 MW in installed capacity for wind energy and 736 MW for solar PV. This reflects the DREI methodology's focus on private-sector investment and large-scale renewable energy, adjusting for the portion of the TSP targets accounted for by public sector investment and small-scale solar PV, respectively.

Baseline Energy Mix

At the end of 2012, Tunisia was estimated to have a total installed electricity generation capacity of 4,117 MW.[23] As set out in Figure 10, the large majority (75%) of electricity is generated by the state utility, Societé Tunisienne de l'Electricité et du Gaz (STEG). This generation is dominated by fossil fuels, primarily gas-powered generation. Nearly all of the remaining electricity is generated by two private sector IPP concessions, both through gas power, and a small percentage of self-production by industrial facilities. Demand has been rising steadily, at a rate of approximately 4% each year. Renewable energy currently accounts for just 3% of Tunisia's grid-connected generation capacity.

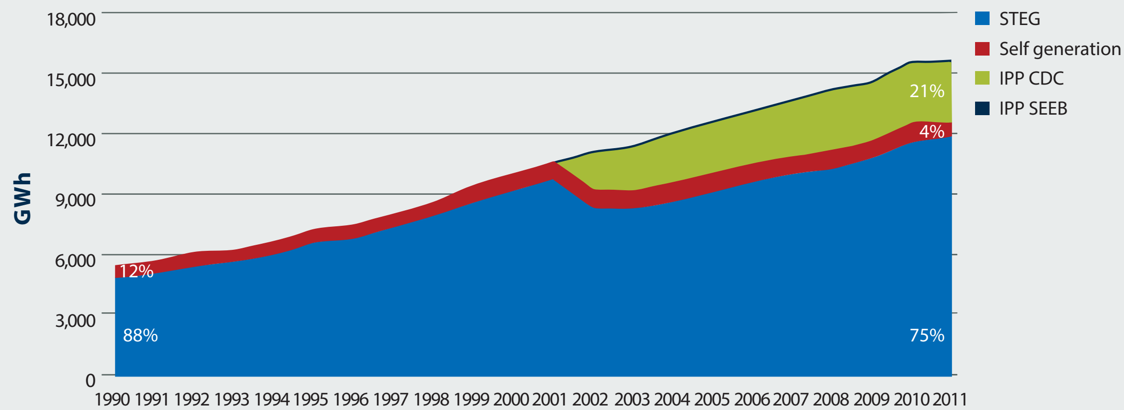
The modelling assumes a marginal baseline (build margin) of 100% gas combined cycle technology (CCGT). Or, in other words, it is assumed that the next private-sector electricity plant to be built in Tunisia will be a gas CCGT plant. The baseline grid emission factor is 0.448 tonnes of CO_2e/MWh.[24]

[22] Sources: Economist Intelligence Unit; Standard & Poor's; UNDP.

[23] Source: Perspectives Climate Change (2014), *Analyse des Possibilités NAMA dans le Secteur d'électricité Renouvelable,* pg. 10.

[24] Source: Bizerte Wind Farm CDM PDD (2012).

Figure 10: Electricity generation in Tunisia (1990 to 2011)



Source: ANME (2013), Maîtrise de l'Energie en Tunisie, Chiffres Clés, 5th Edition.

Renewable Energy Resources

Tunisia has significant wind energy and solar potential. Figure 11 on page 35 shows wind and solar resource maps for Tunisia. Some of the wind sites with strongest wind speeds are found along the northern coast, but there are also good resources in the central and southern regions. The strongest solar radiation is in the south of the country.

The modelling uses a capacity factor of 30% for wind energy, and 21.8% for solar PV. These capacity factors have been taken from recent studies in Tunisia.[25]

Current Status of Wind and Solar PV Investment

The current installed capacity of wind energy in Tunisia is 174 MW[26], spread over two wind farms: Sida Daoud (54MW), which was commissioned in 2009, and Bizerte, which was commissioned in 2012. Both wind farms were publicly funded through STEG. There has been no private sector investment in wind energy to date. There are currently no operational large-scale solar PV plants in Tunisia, either publicly or privately funded.

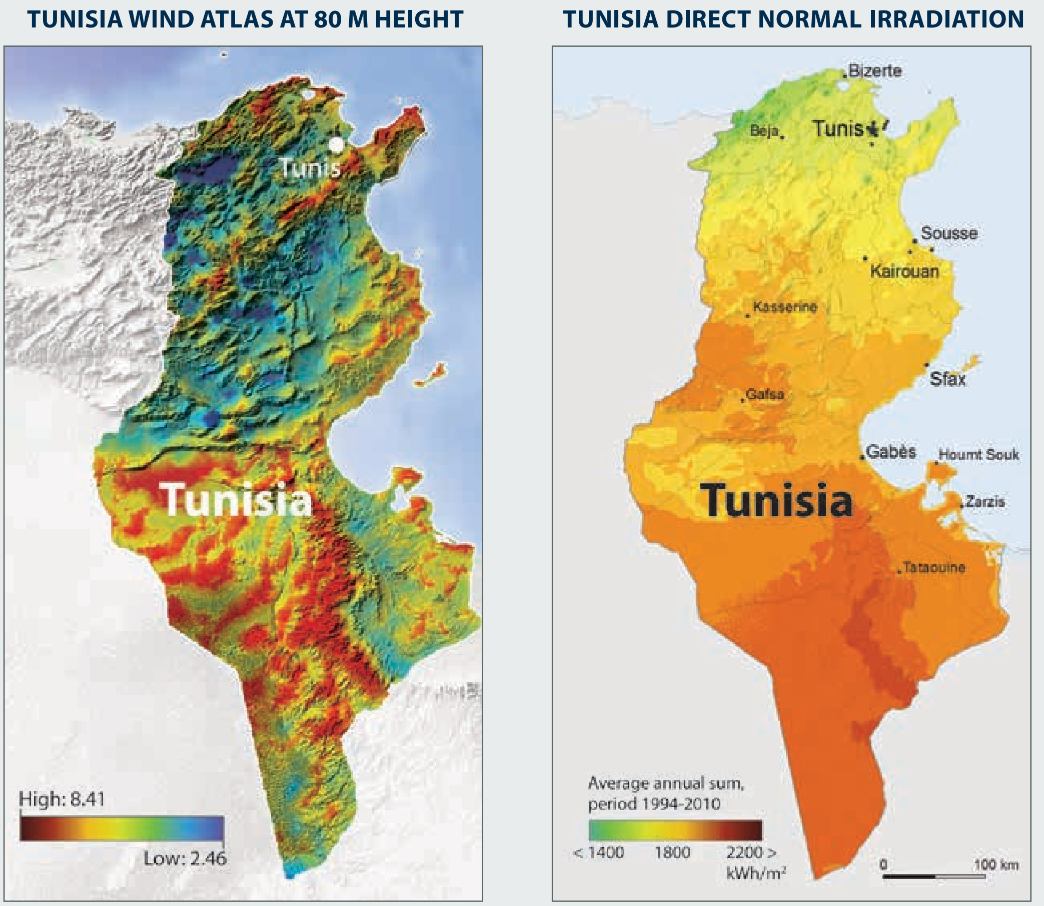
The government has been putting in place policies to attract private-sector investment in renewable energy.

- Since 2008, the main mechanism open to private-sector investment has been self-consumption (auto-production) (Decree No. 2773 of September 2008).
- In September 2014, a new law on attracting investment for the generation of electricity from renewable energy was adopted by the National Constituent Assembly. This new law introduces three principal mechanisms for investment: auto-production, IPP generation and export.

[25] For the wind energy capacity factor, recent studies have used various numbers, including 28.2% (TSP (ANME, 2012) and Energy Mix Study (ANME, 2013)) and 30% (Feed in Tariff Study, ANME (2013)). For the solar PV capacity factor, recent studies have used 21.8% (TSP (ANME, 2012) and Energy Mix Study (ANME, 2013)).

[26] Source: RCREEE (2012), Tunisia Renewable Energy Country Profile.

Figure 11: Resource maps for wind and solar in Tunisia



Source: 3 Tier, SolarGis © 2014 GeoModel Solar.

In addition, a number of international development actors, such as GIZ, AFD and IRENA, have assisted the government of Tunisia with various programmes to support private sector investment.

UNDP's interviews with investors have shown that there is considerable interest today from both domestic and private sector investors. The UNDP-implemented, GEF-financed project, "NAMA Support to the Tunisian Solar Plan", intends to provide direct assistance to two first-of-their-kind renewable energy projects: a 24MW wind farm at Gabes, funded by a domestic private-sector investor; and a 10MW solar PV plant at Tozeur, publicly funded by STEG.

4. Modelling of Wind and Solar PV Energy Promotion in Tunisia

Modelling of Wind and Solar PV Energy Promotion in Tunisia

4

This section describes the DREI modelling for promotion of private sector, large-scale investment in wind energy and solar PV in Tunisia. This section first provides a summary of the approach to the modelling, describing the two scenarios modelled, highlighting key modelling assumptions and setting out the model's barrier, risk and public instrument tables. It then describes the modelling results, organised in terms of the each of the DREI methodology's 4 stages. The full underlying data-sets and assumptions used in preparing the modelling are presented in Annex A.

As in any modelling exercise, the modelling uses a simplified set of data and assumptions. Further in-depth data collection and more comprehensive assumptions can strengthen the robustness of these results.

4.1 THE MODEL'S APPROACH

4.1.1 Modelling Two Core Scenarios in Tunisia

In order to study different public instrument packages, the modelling compares two core scenarios to achieve the 2030 investment targets for large-scale wind energy and solar PV: a *business-as-usual* (BAU) scenario and a post-derisking scenario. Both scenarios take today's (2014) current risk environment in Tunisia as the starting point.

- ***Business-as-usual* scenario.**
  - This scenario assumes that the 2030 investment target is achieved under today's risk environment in Tunisia.
  - The *business-as-usual* scenario uses the current financing costs and terms (capital structure and loan tenor) that an investor encounters in Tunisia.
- ***Post-derisking* scenario.**
  - This scenario assumes that the 2030 investment target is achieved under a derisked investment environment, in which a set of policy derisking and financial derisking instruments are deployed to address current investment risks and associated barriers.
  - As such, the *post-derisking* scenario uses adjusted financing costs and terms (capital structure and loan tenor) compared to the *business-as-usual* scenario, reflecting the impact of derisking instruments in reducing the financing costs and improving financing terms.

4.1.2 Key Modelling Assumptions

The application of the DREI methodology entails a significant amount of data gathering and requires a number of assumptions to be made. In order to keep the scope of the modelling manageable, a set of simplified data and modelling assumptions have been used.

Three key issues associated with the modelling merit highlighting:

- **Variability.** An inherent characteristic of wind energy and solar PV is their variability and lack of dispatchability. Energy planners typically need to balance such renewable energy technologies with dispatchable capacity, and LCOE-based comparisons using variable energy sources can have limitations in not capturing this balancing cost, nor generation costs at peak demand. The modelling does not include balancing costs in the two core scenarios. The modelling anticipates that wind energy and solar PV will be 30% of the generation mix in 2030, and arguably this level can be absorbed into Tunisia's existing gas-powered grid with minimal cost or disruption. Nonetheless, in order to present all perspectives, a sensitivity analysis (see Section 1.4 and 2.4 of the Sensitivity Analyses document) is performed in which balancing costs for variability are modelled.

- **Transmission Lines.** In order to keep the modelling manageable, the modelling assumes that all the wind energy and solar PV sites to meet the 2030 investment target are within 10km of the existing grid. Capital costs related to the upgrade and maintenance of the grid infrastructure in Tunisia are excluded from the analysis.

- **Baseline costs.**

    - Renewable energy investments are made in the context of an existing or evolving (with new installed capacity coming online) electricity generation mix. The modelling takes a marginal baseline (build margin) approach to estimating the baseline costs, assuming new plants take the form of combined cycle gas turbine (CCGT) technology. Tunisia is characterised by rapidly increasing energy demand: consequently, new wind and solar PV installations will likely not replace existing capacity.

    - Private-sector financing costs are used in the marginal baseline mix. This reflects an assumption that Tunisia is seeking to attract private-sector investment irrespective of energy technology, and allows for the comparability of the marginal baseline LCOE with the wind and solar PV energy LCOEs.

    - The gas costs for the marginal baseline have been obtained from STEG's transfer prices to IPPs, as of May 2014. These fuel price assumptions have then been projected into the future using IEA price projections (IEA, 2013).

The full underlying data-sets and assumptions for the modelling are set out in Annex A.

4.1.3 Public Instrument Table

The modelling public instrument table, setting out the stakeholders, barriers and risk categories for large-scale wind energy and solar PV, and the matching public instruments to address these barriers and risks, is set out in full on page 42 (Table 3). This was derived from the generic public instrument table for large-scale, renewable energy in the original DREI report (Waissbein *et al*., 2013). A small number of changes have been made to the generic table; these changes are described in Annex A.

Table 3: The modelling exercise's public instrument table (Part I)

BARRIERS			
RISK CATEGORY	**DESCRIPTION**	**UNDERLYING BARRIERS**	**KEY STAKEHOLDER GROUP**
1. Power Market Risk	Risk arising from limitations and uncertainties in the energy market, and/or sub-optimal regulations to address these limitations and promote renewable energy markets	• *Market outlook:* lack of or uncertainties regarding governmental renewable energy strategy and targets • *Market access and prices:* limitations related to energy market liberalization; uncertainty related to access, the competitive landscape and price outlook for renewable energy; limitations in design of standard PPAs and/or PPA tendering procedures • *Market distortions:* such as high fossil fuel subsidies	Public sector (policymakers, legislators, regulators)
2. Permits Risk	Risk arising from the public sector's inability to efficiently and transparently *administer* renewable energy- related licensing and permits	• Labour-intensive, complex processes and long time-frames for obtaining licences and permits (generation, EIAs, land title) for renewable energy projects • High levels of corruption. No clear recourse mechanisms.	Public sector (administrators)
3. Social Acceptance Risk	Risks arising from lack of awareness and resistance to renewable energy from end-users, special interest groups	• Lack of awareness of renewable energy amongst key stakeholders including: end-users, local residents and special interest groups (e.g. unions) • Social and political resistance related to NIMBY concerns, special interest groups	End-users, general public, media, special interest groups
4. Resource & Technology Risk	Risks arising from use of the renewable energy resource and technology (resource assessment; construction and operational use; hardware purchase and manufacturing)	• *For resource assessment and supply:* inaccuracies in early-stage assessment of renewable energy resource; where applicable (e.g. bioenergy), uncertainties related to future supply and cost of resource • *For planning, construction, operations and maintenance:* uncertainties related to securing land; sub-optimal plant design; lack of local firms offering construction, maintenance services; lack of skilled and experienced local staff; limitations in civil infrastructure (roads etc.) • *For the purchase of hardware:* purchaser's lack of information on quality, reliability and cost of hardware; lack of suitability of hardware to local climatic and physical conditions	Project developers, supply chain

Source: authors; adapted from Derisking Renewable Energy Investment (UNDP, 2013).

MENU OF SELECTED PUBLIC INSTRUMENTS			
POLICY DERISKING INSTRUMENTS		FINANCIAL DERISKING INSTRUMENTS	
ACTIVITY	DESCRIPTION	ACTIVITY	DESCRIPTION
Establish transparent, long-term national renewable energy strategy and targets	Regular updates of national energy planning, including national-level resource inventory/mapping, technology options, and renewable energy target formulation		
Establish a harmonized, well-regulated energy market, with cornerstone instruments to address price and market-access risk for renewable energy projects	(i) Ongoing legislative reform to implement well-designed and harmonized policies; (ii) establish an independent energy market regulator; (iii) Implement FiT and PPA tendering, including well-designed standard PPA		
Policy derisking instruments addressing this barrier, e.g., fossil subsidy reform, are not included in in this Tunisia analysis. Outside scope of analysis.			
Streamline processes for permits	Establish a one-stop-shop for renewable energy permits; reduction of process steps; harmonisation of requirements		
Contract enforcement and recourse mechanisms	Enforce transparent practices, renewable energy related corruption control and fraud avoidance mechanisms; establish effective recourse mechanisms		
Awareness-raising campaigns	Implement active publicity, media and awareness campaign targeting key stakeholder groups .		
Community based involvement at project sites	Establish favourable local (e.g. municipal) policies and promote and pilot community based models (e.g equity stakes in renewable energy projects)		
For wind energy only: assistance on resource assessment	For wind energy only: dissemination of national resource assessment findings.		
Policy derisking instruments addressing this barrier, e.g., assistance on feasbility studies, are not included in in this Tunisia analysis following investor feedback.			
For solar PV only: research and development into technology standards	For solar PV only: Support to pilot projects on solar PV in desert environments		

Table 3: The modelling exercise's public instrument table (Part II)

BARRIERS			
RISK CATEGORY	**DESCRIPTION**	**UNDERLYING BARRIERS**	**KEY STAKEHOLDER GROUP**
5. Grid/Transmission Risk	Risks arising from limitations in grid management and transmission infrastructure	• *Grid code and management:* Lack of standards for the integration of intermittent, renewable energy sources into the grid; limited experience or suboptimal track-record of grid operator with intermittent sources (e.g., grid management and stability). • *Transmission infrastructure:* inadequate or antiquated grid infrastructure, including lack of transmission lines from the renewable energy source to load centres; uncertainties for construction of new transmission infrastructure	Utility (as transmission/grid operator)
6. Counterparty Risk	Risks arising from the utility's poor credit quality and an IPP's reliance on payments	• Limitations in the utility's (electricity purchaser) credit quality, corporate governance, management and operational track-record or outlook; unfavourable policies regarding utility's cost-recovery arrangements	Utility (as electricity purchaser)
7. Financial Sector Risk	Risks arising from general scarcity of investor capital (debt and equity) in the particular country, and investors' lack of information and track record on renewable energy	• *Capital scarcity:* Limited availablity of local or international capital (equity/and or debt) for green infrastructure due to, for example: under-developed local financial sector; policy bias against investors in green energy • *Limited experience with renewable energy:* Lack of information, assessment skills and track-record for renewable energy projects amongst investor community; lack of network effects (investors, investment opportunities) found in established markets; lack of familiarity and skills with project finance structures	Investors (equity and debt)
8. Political Risk	Risks arising from country-specific governance and legal characteristics	• Uncertainty or impediments due to war, terrorism, and/or civil disturbance • Uncertainty due to high political instability; poor governance; poor rule of law and institutions • Uncertainty or impediments due to government policy (currency restrictions, corporate taxes)	National level
9. Currency/ Macro-economic Risk	Risks arising from the broader macroeconomic environment and market dynamics	• Uncertainty due to volatile local currency; unfavourable currency exchange rate movements • Uncertainty around inflation, interest rate outlook due to an unstable macroeconomic environment	National level

Source: authors; adapted from Derisking Renewable Energy Investment (UNDP, 2013).

MENU OF SELECTED PUBLIC INSTRUMENTS			
POLICY DERISKING INSTRUMENTS		**FINANCIAL DERISKING INSTRUMENTS**	
ACTIVITY	**DESCRIPTION**	**ACTIVITY**	**DESCRIPTION**
Strengthen transmission company's operational performance, grid management and formulation of grid code	(i) Develop a grid code for new renewable energy technologies; (ii) sharing of international best practice in grid management	Include a "take-or-pay" clause in the standard PPA	"Take-or-pay" clause in PPA whereby IPP is reimbursed for grid failure (black-out, brown-out) and/or curtailment (due to mismatches in grid management of supply/ demand)
Policy support for national grid infrastructure planning and development	Develop and regularly update a long-term national transmission/grid plan to include intermittent renewable energy	*Financial derisking instruments addressing this barrier, e.g., public loans for grid infrastructure, are not included in in this Tunisia analysis. Outside scope of analysis.*	
Strengthen utility/distribution company's performance	Establish international best practice in utility/distribution company's management, operations and corporate governance; implement sustainable cost recovery policies	Government guarantees or backing for PPA payments	Government (Ministry of Finance) letter of support for PPA payments to IPPs
Financial sector policy reforms	Promote finanical sector policy favourable to long-term infrastructure, including project finance	Financial products by development banks to assist project developers to gain access to capital/funding	Public loans from international financial institutions to IPPs
Policy derisking instruments addressing this barrier, e.g., sponsoring industry conferences, are not included in this Tunisia analysis following investor feedback.			
		Financial derisking instruments addressing this risk category, e.g., political risk insurance, are not included in this Tunisia analysis following investor feedback.	
		Risk sharing mechanisms to address currency risk	Partial indexing of local currency tariffs in PPAs, so that IPPs are reimbursed for local currency depreciation of tariff

4.2 THE MODEL'S RESULTS

4.2.1 Risk Environment (Stage 1)

Interviews

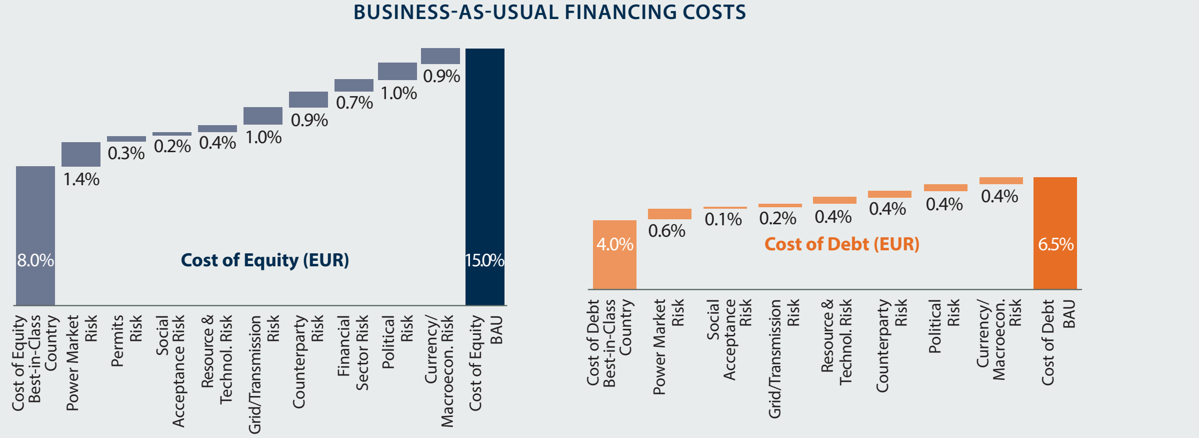
Data for Stage 1 (Risk Environment) of the modelling were gathered from interviews held with 12 domestic and international project developers and investors who are considering, or are actively involved in, large-scale wind and solar PV investment opportunities in Tunisia. The interviews were held in the first half of 2014. In addition, over 20 additional informational interviews were held with other stakeholders during three missions to Tunisia, again in the first half of 2014.

Financing Cost Waterfalls

The analysis of the contribution of investment risks to higher financing costs in Tunisia is shown in the financing cost waterfalls in Figure 12. This analysis was performed jointly for wind energy and solar PV investors. Definitions of each of the risk categories can be found in Table 3.

A brief summary of the qualitative feedback that wind energy and solar PV developers and investors shared in their interviews is provided in Table 4.

Figure 12: Impact of risk categories on financing costs for wind energy and solar PV investments in Tunisia, business-as-usual scenario[27]



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

[27] The financing cost waterfalls shown here were calculated using one single, common set of assumptions and data for both large-scale wind energy and solar PV. It is recognised that the risk profiles of large-scale wind energy and solar PV can differ, most notably for Resource & Technology risk. However, the results of the interviews with wind energy and solar PV investors made clear that these differences are minimal in the Tunisian context. As such, a single, common approach was adopted in order to bring simplicity to the analysis and to avoid multiple result sets.

Table 4: Investor feedback on risk categories for wind energy and solar PV investment in Tunisia

RISK CATEGORY	POLICY DERISKING INSTRUMENTS
Power market risk	This risk category has a high impact on financing costs. Investors comment favourably on a number of aspects of the domestic investment environment. Investors gain confidence from the Tunisian Solar Plan's 2030 renewable energy targets and this demonstration of Tunisia's commitment to renewable energy. ANME is well regarded and is viewed as a strong advocate for promoting renewable energy. Investors are encouraged by the new renewable energy legislation debated (and subsequently passed) by the National Constituent Assembly. Investors also look favourably upon the recent efforts to reform subsidies on fossil fuels, stating that greater transparency in underlying baseline costs will provide them with more confidence to invest. Finally, investors are reassured by the track record of the two gas IPPs that have already successfully entered into PPAs with STEG. Nonetheless, investors raise concerns in a number of areas. Investors do not currently have a strong sense of the details of the new legislation (since implementation of the new law will be dictated by yet-to-be-drafted implementation decrees) and their decision to invest will ultimately depend on well-designed policy. It will be critical for the complementary decrees to the legislation, filling in details, to be well formulated. Some investors also commented on a possible price premium for renewable energy; in general, the lower the price premium for renewable energy, the lower the risk of policy reversal. Investors also noted that there will be a significant administrative and regulatory burden going forward, and would welcome the capacity and staff of the Ministry of Energy and ANME to be further strengthened, or ideally an energy sector regulator to be established.
Permits risk	This risk category has a low impact on financing costs. Investors' views on this risk category were mixed, in part due to the limited empirical experience of private-sector investors with permits to date. One investor commented that, on paper, the existing process and timelines for permits is clear. However, looking ahead, other investors commented that the new legislation has burdensome requirements for permits, and would welcome streamlining of these requirements.
Social acceptance risk	This risk category has a low impact on financing costs. In general, investors do not feel that there is significant risk from local communities. Project sites will likely be in areas with low population density, and project developers actively perform outreach in terms of stakeholder engagement, emphasising employment and tax benefits. Investors did comment on possible resistance to renewable energy, for example from STEG trade unions, due to concerns about private sector involvement.
Resource & technology risk	This risk category has a low impact on financing costs. Investors view this risk category as an area for which they themselves are responsible and expressed confidence that they can manage these risks directly. Nonetheless, one investor warned against designs of bidding processes which result in unnecessary duplication of detailed wind measurements by developers. Investors generally viewed solar PV as having lower resource assessment risk than wind and acknowledged a degree of uncertainty regarding solar PV technology in desert environments.
Grid integration risk	This risk category has a high impact on financing costs. Investors state that STEG is technically very competent, with high quality and technically proficient staff. Investors' concerns arise from STEG's lack of experience with renewable energy and uncertainty regarding STEG's cooperation and transparency with project developers. Investors shared their experiences to date, with examples highlighting a need for a transparent and consistent grid code (to determine project technical specifications), and clear visibility regarding grid planning (to facilitate project grid interconnection).
Counterparty risk	This risk category has a high impact on financing costs. Again, investors commend STEG for its high quality staff and technical competence, and recent efforts to improve operational and financial performance. Nonetheless, investors are concerned by STEG's credit profile and financial status, in large part caused by historically poor cost-recovery (tariff setting). Investors anticipate that some sort of government guarantee, for example a letter of support from the Ministry of Economics and Finance, will be provided to project developers. This risk category is a particular concern for international investors.
Financial sector risk	This risk category has a moderate impact on financing costs. Investors note that Tunisia has an established financial sector, with many large commercial banks. A number of new clean energy equity investors and funds are also being established. These local financial actors are now gaining valuable experience with energy efficiency and small-scale solar PV. At the same time, the domestic financial sector lacks experience with large-scale renewable energy, including modalities such as project finance. Longer-term, there is considerable concern that the domestic financial sector will not be able to supply the large amounts of financing required for the TSP's 2030 targets.
Political risk	This risk category has a high impact on financing costs. Investors are concerned by the recent political instability in Tunisia. In the medium and long term, investors are hopeful that there will be stability. This risk category is particularly important for international investors, and in certain cases can simply rule out investment. Many such investors are currently adopting a "wait-and-see" approach.
Currency/ macroeconomic risk	This risk category has a high impact on financing costs. Investors view the outlook for Tunisia's economy positively. Investors' concern arises from currency risk, since the Tunisian Dinar has a historical track record of depreciation against hard currencies. Currency risk can arise where project developers have financing in hard currency but receive PPA payments in Tunisian Dinars. Commercial foreign exchange hedging can be prohibitively expensive.

Source: interviews with investors and developers.

The results estimate the business-as-usual cost of financing in Tunisia today for wind energy and solar PV to be 15% for the cost of equity (EUR) and 6.5% for the cost of debt (EUR). These are substantially higher than in the best-in-class country, Germany, which is estimated as 8.0% for the cost of equity (EUR) and 4.0% for the cost of debt. As is shown in later results, over the long lifetime of energy investments, the impact of Tunisia's higher financing costs on the competitiveness of renewable energy is significant.

The results identify power-market risk as the predominant risk category contributing to higher financing costs in Tunisia. Grid/transmission risk, counterparty risk, political risk and currency/macroeconomic risk are also all risk categories that significantly elevate financing costs.

4.2.2 Public instruments (Stage 2)

Selection and costing of public instruments

Having identified the key investment risks, a package of public instruments can then be assembled to address them. The modelling adopts a systematic approach to identifying policy instruments: if the financing cost waterfalls (Figure 12) identify an incremental financing cost for a particular risk category, then the matching public instrument (Table 3) is deployed as part of the public instrument package.

The public costs of each selected public instrument are also modelled:

- For wind energy (2030 target: 1,404 MW), the total public instrument cost (2014-2030) is estimated as being EUR 8.5 million in policy derisking instruments and EUR 279.0 million in financial derisking instruments.

- For solar PV (2030 target: 736 MW), the total public instrument cost (2014-2030) is estimated as being EUR 4.4 million in policy derisking instruments and EUR 140.6 million in financial derisking instruments.

As an illustration, for policy derisking instruments the largest cost component is for instruments addressing power market risk, estimated as being EUR 4.4 million (wind energy) and EUR 2.2 million (solar PV). These instruments include: regular updates to long-term renewable energy targets; ongoing energy policy reform; the establishment and ongoing operations of an energy regulator; and administrative costs related to operating FiT and PPA tenders.

For financial derisking instruments, the largest cost component is for instruments addressing financial sector risk, estimated as being EUR 192.1 million (wind) and EUR 96.8 million (solar PV). These instruments consist of concessional public loans, likely provided by multilateral and bilateral development banks. These public loans are modelled given the large quantities of financing necessary to meet the TSP targets and the probable domestic scarcity of capital in the Tunisian financial sector. In addition, other financial derisking instruments modelled include: partial-indexing of the PPA tariff to address currency risk (the foreign exchange rate exposure that IPPs may face due to hard-currency lending with a local-currency-denominated PPA); and "take-or-pay" clauses in the PPA to address grid/transmission risks (black-out/brown-out) and grid management (curtailment).[28]

[28] A "take-or-pay" clause is a clause found in the PPA that essentially allocates risk between parties in the scenario where transmission line failures or curtailment (required by the grid operator) result in the IPP being unable to deliver electricity generated by its renewable energy plant.

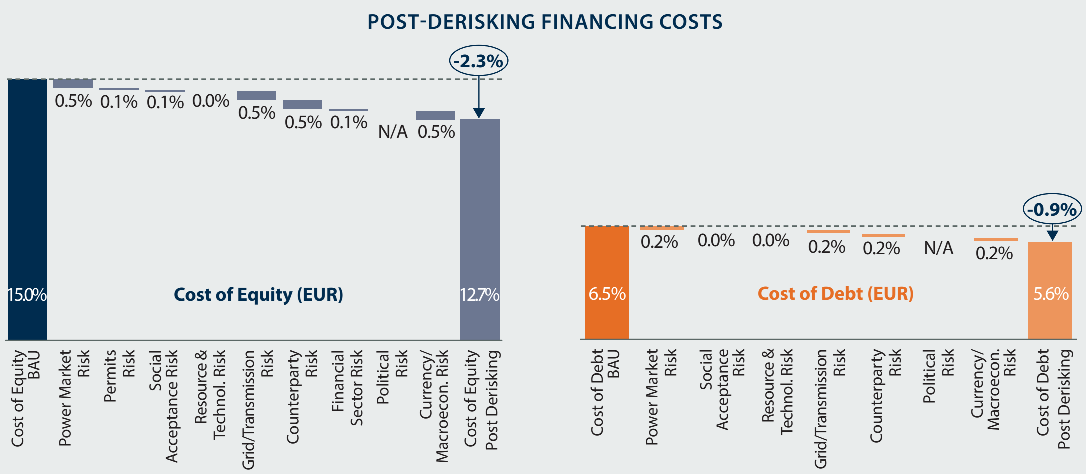
The DREI financial tool also allows for the modelling of the public instrument costs in terms of domestically-funded costs and internationally-funded costs. Internationally-funded costs can be financed by a donor country or a donor institution (such as the Global Environment Facility or the Green Climate Fund). Such an analysis of costs has not been performed for this report, but could be useful for NAMA design.

The full breakdown of each selected public instrument and its cost is provided in Tables 7 (wind energy) and 8 (solar PV). Details of the assumptions and the methodology used to generate the cost estimates are available in Annex A.

Impact of public instruments on financing costs

The impact of the public instruments on reducing financing cost for wind energy and solar PV in Tunisia are shown in Figure 13. Based on the modelling analysis, the selected package of derisking instruments is anticipated to reduce the average cost of equity to 2030 by 2.3%, to 12.7%, and the cost of debt by 0.9%, to 5.6%.

Figure 13: Impact of public derisking instruments on reducing financing costs for wind energy and solar PV in Tunisia



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

4.2.3. Levelised Cost (Stage 3)

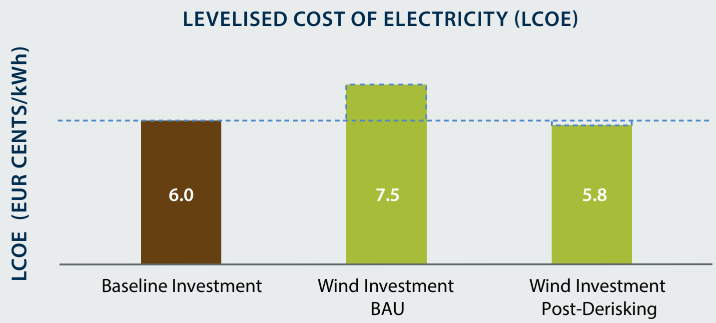
The modelling outputs in terms of LCOEs for wind energy and solar PV are shown in Figures 14 and 15, respectively.

The marginal baseline LCOE, based on private sector investment in gas combined cycle technology, is estimated as being EUR 6.0 cents per kWh.

Wind energy is shown to be more expensive than the baseline cost today, where wind energy's LCOE (*business-as-usual* scenario) is estimated as EUR 7.5 cents per kWh. However, in the *post-derisking* scenario, the package of selected public instruments reduces the LCOE for wind energy to EUR 5.8 cents per kWh. As such, while a price premium of EUR 1.5 cents per kWh would be required for wind energy today in the business-as-usual scenario, in the post-derisking scenario wind energy is actually more competitive and cheaper (by EUR 0.2 cents per kWh) than the baseline cost.

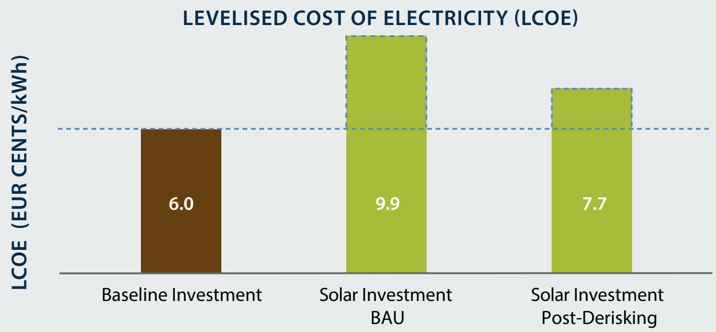
Solar PV is shown to be more expensive than the baseline cost in both the *business-as-usual* and the *post-derisking* scenarios. Nonetheless, the public instrument package reduces the LCOE for wind energy from EUR 9.9 cents per kWh (business-as-usual scenario) to EUR 7.7 cents per kWh (*post-derisking* scenario), reducing the price premium required from EUR 3.9 per kWh to EUR 1.7 cents per kWh.

Figure 14: LCOEs for the baseline and wind energy investment in Tunisia



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

Figure 15: LCOEs for the baseline and solar PV investment in Tunisia



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

4.2.4 Evaluation (Stage 4)

Performance Metrics

The model's performance metrics, evaluating the impact of derisking on the 2030 targets for wind and solar PV investment in Tunisia, are shown in Figures 16 and 17.

Each of the four performance metrics takes a different perspective in assessing the performance of the derisking instrument package.

- The **investment leverage ratio** shows the efficiency of public instruments in attracting investment, comparing the total cost of public instruments with the resulting private-sector investment.

- The **savings ratio** takes a social perspective, comparing the cost of derisking instruments deployed versus the economic savings that accrue to society from deploying the instruments.

- The **affordability** metric takes an electricity consumer perspective, comparing the generation cost of wind energy or solar PV in the post-derisking scenario with the original BAU scenario.

- The **carbon abatement** metric takes a climate change mitigation perspective, considering the carbon abatement potential and comparing the carbon abatement costs (the cost per tonne of CO_2e abated). This can be a useful metric for NAMAs, and for comparing carbon prices.

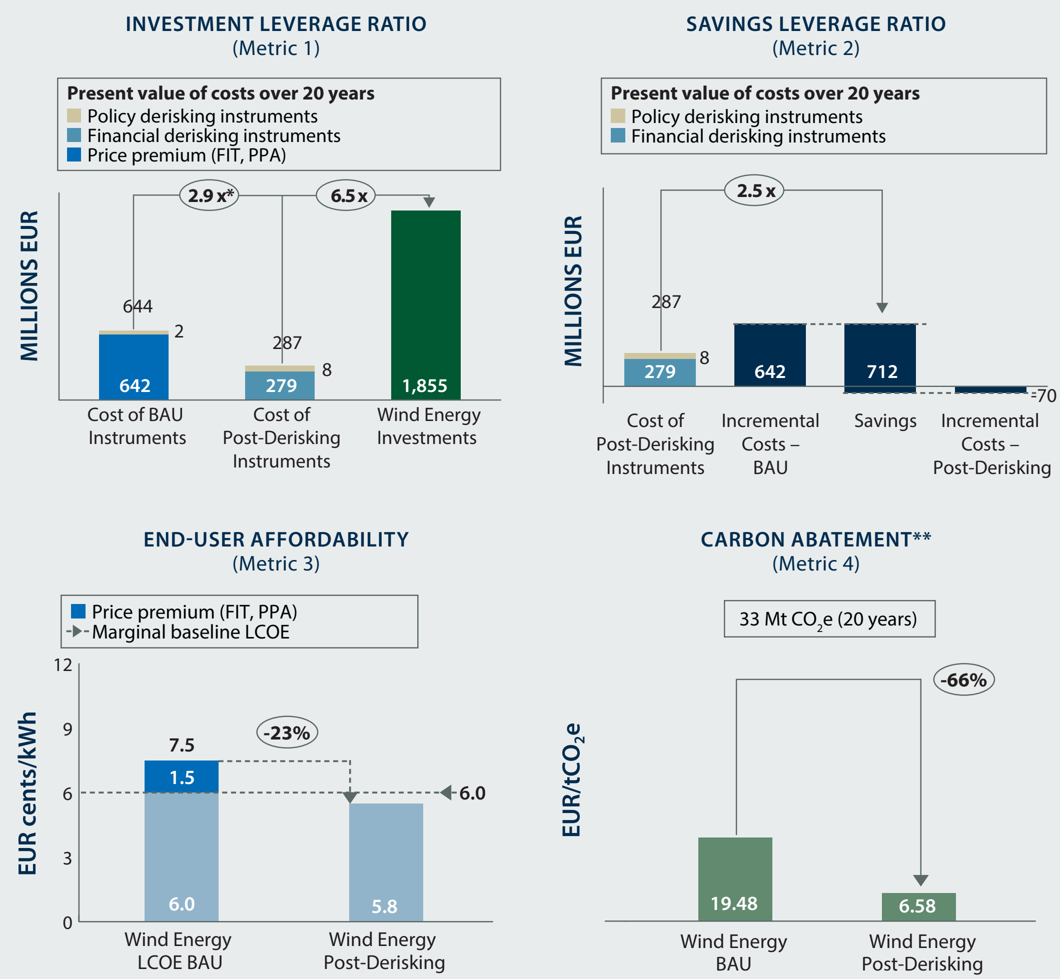
Taken as a whole, the performance metrics for wind and solar PV demonstrate how the public deployment of derisking instruments to achieve the Tunisia Solar Plan can significantly increase the competitiveness and affordability of both wind energy and solar PV in Tunisia.

For example, for both wind energy and solar PV the investment leverage ratio shows that derisking is an efficient use of public funding.

- For wind energy, the 1,404 MW 2030 TSP target is estimated to require EUR 1,855 million in private sector investment. In the *business-as-usual* scenario, with today's risk environment, achieving the TSP 2030 target is estimated to require a price premium of EUR 642 million over 20 years. As such, the investment leverage ratio is 2.9x. In the *post-derisking* scenario, a package of derisking instruments estimated as costing EUR 275 million eliminates the need for any price premium. In this case, the investment leverage ratio increases to 6.5x.

- For solar PV, the 736 MW 2030 TSP target is estimated to require EUR 935 million in private sector investment. The modelling shows that solar PV will require a price premium in both the business-as-usual scenario and the post-derisking scenario. Nonetheless, a package of derisking instruments estimated to cost EUR 130 million can still be beneficial, reducing the price premium from EUR 634 million to EUR 276 million over 20 years. In this way, the leverage ratio increases from 1.5x (*business-as-usual* scenario) to 2.2x (*post-derisking* scenario).

Figure 16: Performance metrics for the selected package of derisking instruments in promoting 1,404 MW of wind energy investment in Tunisia

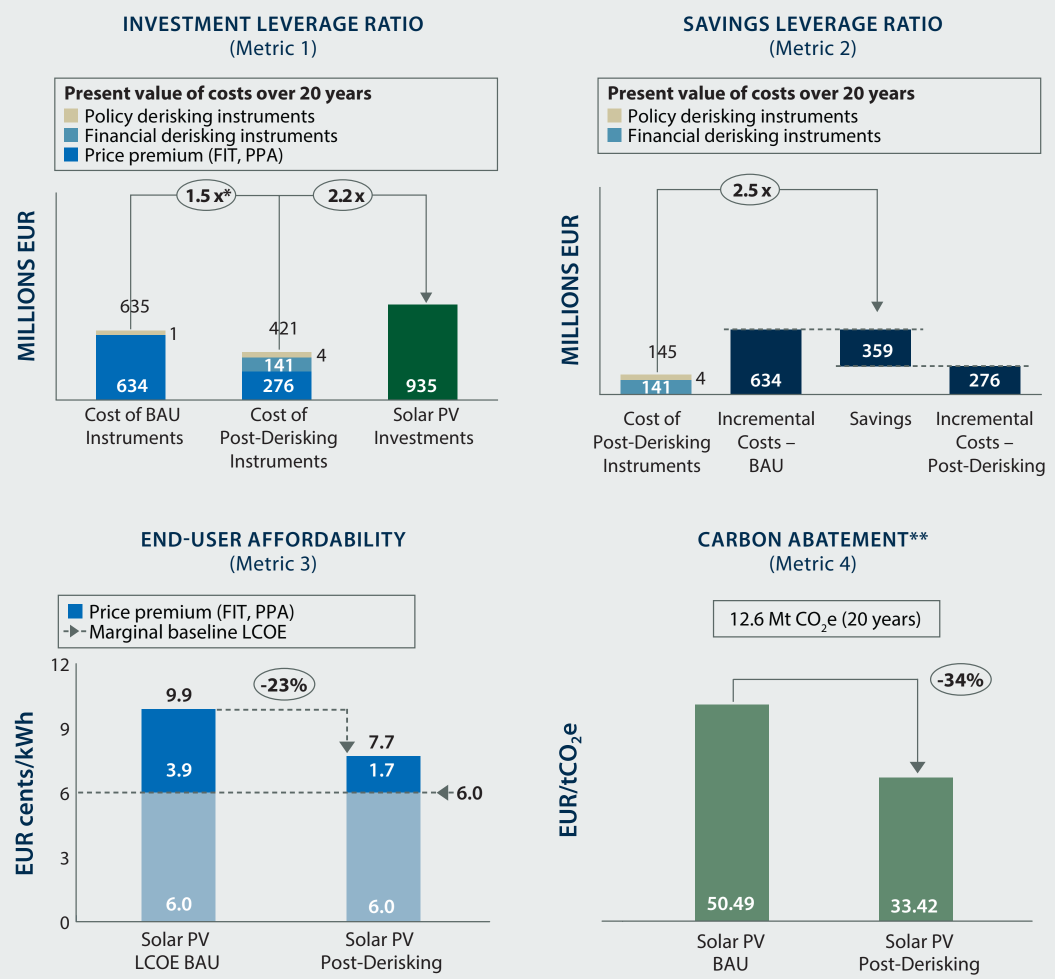


Source: modelling; see Table 7 and Annex A for details on assumptions and methodology.

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

**Components of carbon abatement figures: *business-as-usual* scenario: policy derisking instruments EUR 0.05, financial derisking instruments EUR 0.00, price premium EUR 19.43. *Post-derisking* scenario, EUR 0.26, EUR 8.44 and EUR -2.11 respectively.

Figure 17: Performance metrics for the selected package of derisking instruments in promoting 736 MW of solar PV investment in Tunisia



Source: modelling; see Table 8 and Annex A for details on assumptions and methodology.

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

**Components of carbon abatement figures: *business-as-usual* scenario: policy derisking instruments EUR 0.06, financial derisking instruments EUR 0.00, price premium EUR 50.42. *Post-derisking* scenario, EUR 0.35, EUR 11.17 and EUR 21.90 respectively.

Sensitivities

An initial set of sensitivity analyses has been performed for both wind energy and solar PV. The objective of performing the sensitivity analyses is to gain a better understanding of the robustness of the outputs and to be able to test different scenarios.

The LCOE outputs for the sensitivity analyses are summarised in Tables 5 and 6 below. The full results for each sensitivity analysis (financing cost waterfalls, LCOE outputs and performance metrics) are set out in the Sensitivity Analysis document complementary to this report.

Three broad types of sensitivity analysis have been performed.

1. **Sensitivity analyses varying key input assumptions.** These have been performed for the following input assumptions: (i) investment costs, (ii) capacity factors, (iii) gas fuel costs and (iv)financing costs. The sensitivity analyses give an indication of the degree to which each input parameter affects the outputs. As an illustration, for wind energy, an increase in the capacity factor from 30% (base case) to 35% (sensitivity analysis) reduces the LCOE for wind energy in the BAU scenario from EUR 7.5 cents per kWh to EUR 6.4 cents per kWh.

2. **Sensitivity analyses varying public instrument selection.** This sensitivity analysis examines different combinations of public instruments. This can assist in identifying the most effective combination of instruments, and the relative cost-effectiveness of different instruments. The modelling performs a simplified version of this type of sensitivity, examining two scenarios: the first, a scenario which uses only a package of policy derisking instruments; the second, a scenario which uses only financial derisking instruments.

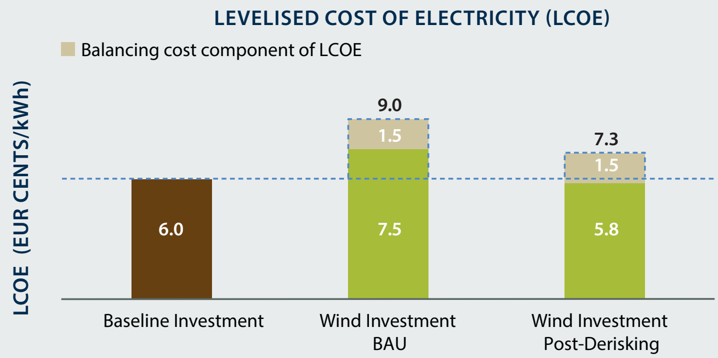
   For example, for solar PV, the scenario with only policy derisking instruments, in which the instruments are estimated as costing EUR 4.4 million to 2030, reduces the LCOE from EUR 9.9 cents per kWh to EUR 9.0 cents per kWh. The financial derisking-only scenario, in which the instruments are estimated to cost EUR 140.6 million to 2030, reduces the LCOE from EUR 9.9 cents per kWh to EUR 8.1 cents per kWh.

3. **Sensitivity analyses on balancing costs.** This sensitivity analysis incorporates the potential cost of balancing renewable energy technologies with dispatchable capacity, reflecting the variable nature of wind and solar PV energy. There is considerable debate about whether balancing costs should be included when examining the competitiveness of renewable energy.[29] This sensitivity analysis therefore represents a conservative viewpoint on wind energy and solar PV in Tunisia. Details of the full methodology used to calculate balancing costs can be found in Annex A.4.

   Figures 18 and 19 below show the LCOEs that include balancing costs. For wind energy, the balancing costs are estimated to add EUR 1.5 cents per kWh to the LCOE. For solar PV, the balancing costs are estimated to add EUR 0.8 cents per kWh to the LCOE. Balancing costs are lower for solar PV than for wind energy, as solar PV generation aligns more closely with overall system demand in Tunisia, with sunshine at midday and in the afternoon corresponding to peak demand.

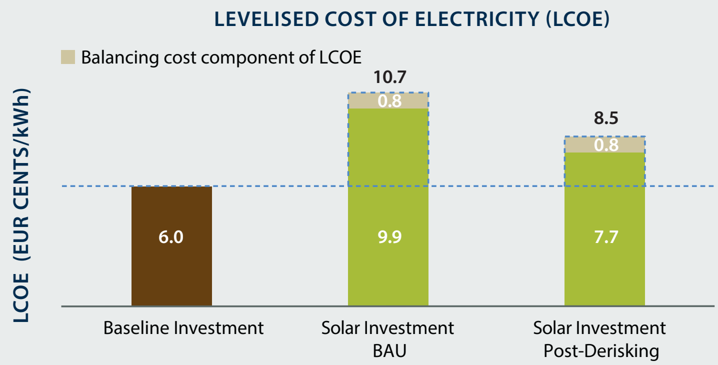
[29] For example, it can be argued that balancing costs need not be modelled because the model assumes that wind energy and solar PV will account for only 30% of the generation mix in 2030, and that this level of renewable energy generation can be absorbed into Tunisia's existing gas-powered grid with minimal cost of disruption.

Figure 18: Wind energy sensitivity to balancing costs: LCOE outputs



Source: modelling; see Table 7, Annex A and the Sensitivity Analyses document for details of assumptions and methodology.

Figure 19: Solar PV sensitivity to balancing costs: LCOE outputs



Source: modelling; see Table 8, Annex A and the Sensitivity Analyses document for details of assumptions and methodology.

As shown in Table 5 and 6, the results of the sensitivity analyses identify the assumptions for (i) investment costs, (ii) capacity factors, (iii) gas costs and (iv) financing costs (cost of debt, cost of equity) as all having a large impact on the competitiveness of wind energy and solar PV.

The assumptions about investment costs (i.e. the cost of hardware, such as wind turbines and solar panels) have particular potential for improving the overall competitiveness of wind energy and solar PV in Tunisia. Globally, the costs of renewable energy hardware have shown consistent reductions over time. The model's base case uses data for current (2014) investment costs for this assumption. Should investment costs continue to fall, the sensitivity analysis examines a scenario which uses lower (2022) investment costs.[30] The lower 2022 investment costs result in significant reductions of both wind energy and solar PV LCOEs. For example, the generation cost of wind energy in the *post-derisking* scenario falls from EUR 5.8 cents per kWh to EUR 5.2 cents per kWh; similarly, the *post-derisking* generation costs of solar PV fall from EUR 7.7 cents per kWh to EUR 6.6 cents per kWh. In this scenario, wind energy would be considerably cheaper than the baseline energy cost of EUR 6.0 cents per kWh, and solar PV would now only require a EUR 0.6 cents per kWh price premium.

[30] The modelling period is 2014-2030. The year 2022 is selected as it reflects the mid-point of this period.

Table 5: Wind energy: summary of LCOE outputs for sensitivity analysis. (All units EUR cents per kWh)

TYPE OF SENSITIVITY	DESCRIPTION OF SENSITIVITY	BASELINE LCOE	WIND BAU LCOE	WIND POST-DERISKING LCOE
Base Case	**None**	**6.0 cents**	**7.5 cents**	**5.8 cents**
Wind Investment Costs	Lower investment costs. Uses 2022 investment cost estimate (Base case is 2014 investment cost)	–	6.8 cents	5.2 cents
Wind Capacity Factor	Higher capacity factor. Sensitivity uses 35% (Base case is 30%)	–	6.4 cents	5.0 cents
Gas Costs for Baseline	20% higher gas cost projections 20% lower gas cost projections	6.8 cents 5.1 cents	–	–
Financing Costs	1% point higher financing costs (equity=16.0%, debt=7.5%)	–	7.9 cents	6.0 cents
	1% point lower financing costs (equity=14.0%, debt=5.5%)	–	7.0 cents	5.6 cents
	(Base case is equity=15.0%, debt=6.5 %)			
Policy Derisking Instruments Only	Only policy derisking instruments selected. Instrument cost is EUR 8.5 million (Base case includes both policy and financial derisking)	–	–	6.8 cents
Financial Derisking Instruments Only	Only financial derisking instruments selected. Instrument cost is EUR 279.0 million (Base case includes both policy and financial derisking)	–	–	6.1 cents
Wind Balancing Costs	Includes estimates of balancing costs in LCOE. (Base case excludes balancing costs)	–	9.0 cents	7.3 cents

Source: modelling exercise; see Table 7, Annex A and the Sensitivity Analyses document for details of assumptions, methodology and further results.

Table 6: Solar PV: summary of LCOE outputs for sensitivity analysis. (All units EUR cents per kWh)

TYPE OF SENSITIVITY	DESCRIPTION OF SENSITIVITY	BASELINE LCOE	SOLAR PV BAU LCOE	SOLAR PV POST-DERISKING LCOE
Base Case	**None**	**6.0 cents**	**9.9 cents**	**7.7 cents**
Solar PV Investment Costs	Lower investment costs. Uses 2022 investment cost estimate (Base case is 2014 investment cost)	–	8.5 cents	6.6 cents
Gas Costs for Baseline	20% higher gas cost projections 20% lower gas cost projections	6.8 cents 5.1 cents	–	–
Financing Costs	% point higher financing costs (equity=16.0%, debt=7.5%)	–	10.5 cents	7.9 cents
	1% point lower financing costs (equity=14.0%, debt=5.5%)	–	9.3 cents	7.4 cents
	(Base case is equity=15.0%, debt=6.5 %)			
Policy Derisking Instruments Only	Only policy derisking instruments selected. Instrument cost is EUR 4.4 million (Base case includes both policy and financial derisking)	–	–	9.0 cents
Financial Derisking Instruments Only	Only financial derisking instruments selected. Instrument cost is EUR 140.6 million (Base case includes both policy and financial derisking)	–	–	8.1 cents
Solar PV Balancing Costs	Includes estimates of balancing costs in LCOE. (Base case excludes balancing costs)	–	10.7 cents	8.5 cents

Source: modelling exercise; see Table 8, Annex A and the Sensitivity Analyses document for details of assumptions, methodology and further results.

Table 7: Summary modelling assumptions for wind energy in Tunisia

WIND TARGET AND RESOURCES	
2030 Target (in MW)	1,404
Capacity Factor (%)	30%
Total Annual Energy Production for Target (in MWh)	3,689,712
MARGINAL BASELINE	
Energy Mix Coal	
Natural Gas (Combined Cycle Technology) (%)	100%
Grid Emission Factor (tCO_2e/MWh)	0.448
GENERAL COUNTRY INPUTS	
Effective Corporate Tax Rate (%)	30%
Public Cost of Capital (%)	6%

	***BUSINESS-AS-USUAL* SCENARIO**		***POST-DERISKING* SCENARIO**
FINANCING COSTS			
Capital Structure			
Debt/Equity Split	70%/30%		72.5%/27.5%
Cost of Debt			
Concessional public loan	N/A		4.0%
Commercial loans with public guarantees	N/A		N/A
Commercial loans without public guarantees	6.5%		5.6%
Loan Tenor			
Concessional public loan	N/A		20 years
Commercial loans with public guarantees	N/A		N/A
Commercial loans without public guarantees	10 years		11 years
Cost of Equity	15%		12.7%
Weighted Average Cost of Capital (WACC) (After-tax)	7.7%		5.9%
INVESTMENT			
Total Investment (EUR million)	€1,854.5		€1,854.5
Debt (EUR million)			
Concessional public loan	€0.0		€672.3
Commercial loans with public guarantees	€0.0		€0.0
Commercial loans without public guarantees	€1,298.2		€672.3
Equity (ERU million)	€556.4		€510.0
COST OF PUBLIC INSTRUMENTS			
Policy Derisking Instruments (EUR million, present value)			
Power Market Risk Instruments	€1.6		€4.4
Permits Risk Instruments	N/A		€0.8
Social Acceptance Risk Instruments	N/A		€0.8
Resource & Technology Risk Instruments	N/A		€0.7
Grid/Transmission Risk Instruments	N/A		€0.8
Counterparty Risk Instruments	N/A		€0.4
Financial Sector Risk Instruments	N/A		€0.5
Total	€1.6		€8.5
Financial Derisking Instruments (EUR million, present value)			
Grid/Transmission Risk Instruments	N/A		€23.1
Counterparty Risk Instruments	N/A		N/A
Financial Sector Risk Instruments	N/A		N/A
Public Loans	N/A		€192.1
Public Guarantees for Commercial Loans	N/A		N/A
Political risk insurance	N/A		N/A
Currency/Macro Risk Instruments	N/A		€63.8
Total	N/A		€279.0
Direct Financial Incentives (EUR million)			
Present Value of 20 year PPA Premium	€642.3		€0.0

Source: modelling; see Annex A for details of assumptions and methodology.
Financing costs are average costs from 2014-2030.

Table 8: Summary modelling assumptions for solar PV in Tunisia

SOLAR PV TARGET AND RESOURCES	
2030 Target (in MW)	736
Capacity Factor (%)	21.8%
Total Annual Energy Production for Target (in MWh)	1,404,288
MARGINAL BASELINE	
Energy Mix Coal	
Natural Gas (Combined Cycle Technology) (%)	100%
Grid Emission Factor (tCO_2e/MWh)	0.448
GENERAL COUNTRY INPUTS	
Effective Corporate Tax Rate (%)	30%
Public Cost of Capital (%)	6%

	BUSINESS-AS-USUAL SCENARIO		*POST-DERISKING* SCENARIO
FINANCING COSTS			
Capital Structure			
Debt/Equity Split	70%/30%		72.5%/27.5%
Cost of Debt			
Concessional public loan	N/A		4.0%
Commercial loans with public guarantees	N/A		N/A
Commercial loans without public guarantees	6.5%		5.6%
Loan Tenor			
Concessional public loan	N/A		20 years
Commercial loans with public guarantees	N/A		N/A
Commercial loans without public guarantees	10 years		11 years
Cost of Equity	15%		12.7%
Weighted Average Cost of Capital (WACC) (After-tax)	7.7%		5.9%
INVESTMENT			
Total Investment (EUR million)	€934.6		€934.6
Debt (EUR million)			
Concessional public loan	€0.0		€338.8
Commercial loans with public guarantees	€0.0		€0.0
Commercial loans without public guarantees	€654.2		€338.8
Equity (ERU million)	€280.4		€257.0
COST OF PUBLIC INSTRUMENTS			
Policy Derisking Instruments (EUR million, present value)			
Power Market Risk Instruments	€0.8		€2.2
Permits Risk Instruments	N/A		€0.4
Social Acceptance Risk Instruments	N/A		€0.5
Resource & Technology Risk Instruments	N/A		€0.4
Grid/Transmission Risk Instruments	N/A		€0.4
Counterparty Risk Instruments	N/A		€0.2
Financial Sector Risk Instruments	N/A		€0.2
Total	€0.8		€4.4
Financial Derisking Instruments (EUR million, present value)			
Grid/Transmission Risk Instruments	N/A		€11.6
Counterparty Risk Instruments	N/A		N/A
Financial Sector Risk Instruments	N/A		N/A
Public Loans	N/A		€96.8
Public Guarantees for Commercial Loans	N/A		N/A
Political risk insurance	N/A		N/A
Currency/Macro Risk Instruments	N/A		€32.2
Total	N/A		€140.6
Direct Financial Incentives (EUR million)			
Present Value of 20 year PPA Premium	€634.5		€275.6

Source: modelling; see Annex A for details of assumptions and methodology.
Financing costs are average costs from 2014-2030.

Conclusions

The results in this report should not be interpreted as a definitive quantitative analysis of wind energy and solar PV in Tunisia but, rather, as one contribution to the larger policy decision-making process. It is hoped that the findings in this report can be compared, contrasted and combined with other analyses.

Implications for promoting renewable energy in Tunisia

The results confirm that financing costs for wind energy and solar PV in Tunisia are currently high, particularly in comparison to countries with more favourable investment environments. The cost of equity for wind energy and solar PV in Tunisia today is estimated as being 15.0% (EUR), and the cost of debt as 6.5% (EUR).[31] The modelling identifies nine different risk categories that contribute to these higher financing costs in Tunisia. Power market risk – which concerns risks related to regulations and pricing mechanisms for renewable energy – is identified as being the most significant risk category, contributing an estimated 1.4% to the cost of equity. Four other categories – grid/transmission risk, counterparty risk, political risk and currency/macroeconomic risk – are also large contributors to high financing costs, increasing the cost of equity by approximately 1.0% each.

"A key conclusion is that investing in derisking measures is a cost-effective approach when measured against paying a premium price for wind energy and solar PV."

A key conclusion from the modelling is that investing in derisking measures to target these investment risks is a cost-effective approach to achieving the investment objectives of the Tunisian Solar Plan. The derisking measures bring down the generation cost of wind energy from EUR 7.5 cents per kWh to EUR 5.8 cents per kWh, and solar PV energy from EUR 9.9 cents per kWh to EUR 7.7 cents per kWh. These lower generation costs have important implications for affordability for Tunisian end-users. The modelling also demonstrates that investing in derisking measures is good value for money when measured against paying a premium price for wind energy and solar PV.

- For wind energy, in the *business-as-usual* scenario, the modelling estimates that a premium price totalling EUR 642 million will be required over the next 20 years to achieve the TSP target. However, if a total investment of EUR 287 million is made in derisking measures (EUR 20.5 million per year until 2030[32]), wind energy then becomes cheaper than the baseline energy cost, eradicating the need for a premium price and saving EUR 712 million over 20 years.

- For solar PV, in the *business-as-usual* scenario, the modelling estimates that a premium price totalling EUR 634 million will be required over the next 20 years to achieve the TSP target. However, if a total investment of EUR 145 million is made in derisking measures (EUR 8.5 million per year until 2030[33]), solar PV generation costs fall, and the premium price is reduced by EUR 359 million over 20 years. The new premium price requirement is EUR 276 million over 20 years.

Overall, the results indicate that all derisking instruments that can be immediately implemented should, if possible, be prioritised before resorting to premium prices to compensate for any residual risks.

[31] Euro denominated cost of equity and cost of debt.

[32] Annual costs are given in 2014 Euros.

[33] The modelling period is 2014-2030. The year 2022 is selected as it reflects the mid-point of this period.

Applicability of DREI methodology to NAMA design

This report represents the first instance of the DREI methodology being used to assist with the design of a NAMA. The results indicate that the DREI methodology appears to be well suited to NAMA design. It provides a structured framework to quantify and itemise the various components of a NAMA, including the costs of investments, the selection and cost of public instruments, and the anticipated greenhouse gas emission reductions.

The DREI methodology used will now be applied in the ANME-executed, GEF-financed NAMA TSP project. The project intends to apply the DREI methodology to wind energy, solar PV and CSP. It is anticipated that these analyses will build on and further develop the modelling presented in this report. For example, should the NAMA design include carbon crediting, the analysis will place increased emphasis on this modality.

"The DREI methodology will now be applied to develop the NAMA for the Tunisia Solar Plan."

Further Areas of Work

The modelling team identified a number of areas of further work for future applications of the DREI methodology in Tunisia.

- **Role of fossil-fuel subsidies.** Due to limitations in data, it was not possible to incorporate fossil fuel subsidies in the modelling. Such subsidies are currently undergoing reform in Tunisia and, once there is better data and visibility, the modelling can be strengthened by including them. These subsidies can have a large impact on the attractiveness of wind and solar PV.

- **Sensitivity analyses.** The analysis performed for this modelling was preliminary in nature. Further work may include: (i) additional gathering of data and refining of assumptions, for example relating to balancing costs, (ii) examining combined sensitivities (changes to multiple inputs at the same time), in addition to the individual sensitivities performed so far; and (iii) examining the probability that a key input parameter may change.

- **Cost analyses.** The costing of instruments for this modelling was preliminary in nature. There is a need for further data gathering and methodology development for the costing of both policy derisking and financial derisking instruments. In addition, future modelling can examine the costs according to funding sources, allocating costs to domestic, international and market sources.

Annexes

Annexes

ANNEX A. METHODOLOGY AND DATA

This annex sets out the methodology, assumptions and data that have been used in performing the modelling described in this report.

The modelling closely follows the methodology set out in the UNDP *Derisking Renewable Energy Investment Report* (Waissbein *et al.*, 2013) ("original DREI report"). This annex is organised in line with the four stages of the DREI report's framework: the Risk Environment Stage (Stage 1), the Public Instrument Stage (Stage 2), the Levelised Cost Stage (Stage 3) and the Evaluation Stage (Stage 4). Both wind energy and solar PV are addressed under each stage.

In addition, the modelling uses the financial tool (in Microsoft Excel) created for the DREI report framework. The financial tool is denominated in 2014 Euros and covers a core period from January 1, 2014 (approximating the present time) to December 31, 2030 (Tunisia's 2030 renewable energy targets). Generation technologies may have asset lifetimes which extend beyond 2030, and this is captured by the financial tool.

The original DREI report and the financial tool are available for download at www.undp.org/DREI.

A.1. Stage 1 – Risk Environment

The data for the Risk Environment Stage come from three principal sources:

- UNDP's experience with, and analysis of, large-scale renewable energy, in particular as set out in the original DREI report (2013).
- Multiple information interviews with relevant stakeholders and experts, such as government officials (in particular ANME), international development practitioners and domestic renewable energy actors.
- 12 structured interviews with investors and developers in wind energy and solar PV in Tunisia and the best-in-class country.

In order to gather these data, the UNDP project team made three field missions to Tunisia in the period between late-2013 and mid-2014.

Joint Treatment of Wind Energy and Solar PV

The Risk Environment Stage (Stage 1) is performed using one single, common set of assumptions and data for both large-scale wind energy and solar PV.

It is recognised that the risk profiles of large-scale wind energy and solar PV can differ, most notably for Resource & Technology risk. However, the results of the interviews with wind energy and solar PV investors made clear that these differences are minimal in the Tunisian context. As such, a single, common approach was adopted in order to bring simplicity to the analysis and to avoid multiple result sets.

Deriving a Multi-Stakeholder Barrier and Risk Table

The multi-stakeholder barrier and risk table for wind energy and solar PV is derived from the generic table for large-scale, renewable energy introduced in the original DREI report, (Section 2.1.1). It is composed of 9 risk categories and 20 underlying barriers. These risk categories, barriers and their definitions can be found in Table 3 in the body of this report.

Calculating the Impact of Risk Categories on Higher Financing Costs

The basis of the financing cost waterfalls produced by the modelling is structured, quantitative interviews undertaken with wind energy investors and developers. The interviews were performed on a confidential basis, and all data across interviews were aggregated together. The interviews and processing of data followed the methodology described in Box 3 below, with investors scoring each risk category according to (i) the probability of occurrence of negative events and (ii) the level of financial impact of these events (should they occur), as well as also scoring (iii) the effectiveness of public instruments to address each risk category. Investors were also asked to provide estimates of their cost of equity, cost of debt, capital structure and loan tenors. Interviewees were provided beforehand with an information document setting out key definitions and questions, and the typical interview took between 45 and 90 minutes.

Box 3: Methodology for quantifying the impact of risk categories on higher financing costs

1. Interviews

Interviews were held with debt and equity investors active in wind energy and solar PV in Tunisia, as well as in the selected best-in-class country, Germany. The interviewees were asked to provide two types of data:

- Scores for the various risk categories identified in the barrier and risk framework. The two interview questions used to quantify the risk categories are set out in Figure 20.
- The current cost of financing for making an investment today,which represents the end-point of the waterfall (or the starting point in the case of the best-in-class country).

Figure 20: Interview questions to quantify the impact of risk categories on the cost of equity and debt

Q1: How would you rate the probability that the events underlying the particular risk category occur?

UNLIKELY **1** ○ **2** ○ **3** ○ **4** ○ **5** ○ VERY LIKELY

Q2: How would you rate the financial impact of the events underlying the particular risk category, should the events occur?

LOW IMPACT **1** ○ **2** ○ **3** ○ **4** ○ **5** ○ HIGH IMPACT

(Continued over the next page)

Box 3: Methodology for quantifying the impact of risk categories on higher financing costs (Continued)

2. Processing the data gathered

The data gathered from interviews are then processed. The methodology involves identifying the total difference in the cost of equity or debt between the developing country (Tunisia) and the best-in-class developed country (Germany). This figure for the total difference reflects the total additional financing cost in the developing country.

The interview scores provided for each risk category address both components of risk: the probability of a negative event occuring above the probability of such an event occuring in a best-in-class country and the financial impact of the event if such an event occurs. (See original DREI report, Section 2.1.1). These two ratings are then multiplied to obtain a total score per risk category. These total risk scores are then used to pro-rate and apportion the total difference in the cost of equity or debt.

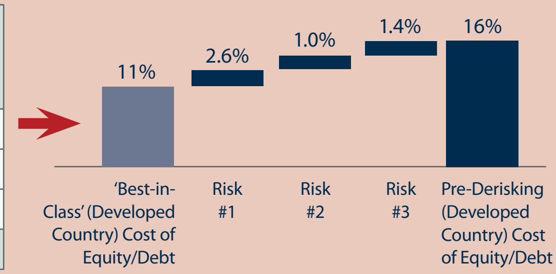
A very simplified example,demonstrating the basic approach, is demonstrated in Figure 21.

Figure 21: Illustrative simplified application of the methodology to determine the impact of risk categories on increasing financing costs

COST OF EQUITY	
Developing Country	16%
Best-in-class Developed Country	11%
Total Diference	**5%**

INVESTOR RISK SCORES FOR COST OF EQUITY	Incremental Score for Probability		Score for Impact		**Total Risk Score**
Risk Category # 1	4	X	4	=	16
Risk Category # 2	2	X	3	=	6
Risk Category # 3	3	X	3	=	9
			Total Across all Risks		**31**

PRO-RATING RISK SCORES ACROSS COST OF EQUITY	Pro-rated Risk Score		Total Difference for Cost of Equity		**Risk Category Cost of Equity**
Risk Category # 1	16/31	X	5%	=	2.6%
Risk Category # 2	6/31	X	5%	=	1.0%
Risk Category # 3	9/31	X	5%	=	1.4%
			Total Across all Risks		**5.0%**



In addition, the following key steps have been taken in calculating the financing cost waterfalls:

- In order to make interviews comparable, investors were asked to provide their scores while taking into account a list of eight key assumptions regarding wind energy or solar PV investment, as set out in Boxes 4 and 5 respectively. To maintain consistency, these assumptions were subsequently used to shape the inputs in the LCOE calculation for wind energy in Stage 3.

Box 4: The eight investment assumptions for wind energy in Tunisia

1. Provide scores based on the current investment environment in the country today
2. Assume you have the opportunity to invest in a 50-100 MW on-shore wind park
3. Assume 2-3 MW class turbines from a quality manufacturer with a proven track record
4. Assume a build-own-operate (BOO) business model
5. Assume a comprehensive O&M contract
6. Assume that well-maintained transmission lines with free capacities are located within 10km of the project site
7. Assume an EPC construction sub-contract with high penalties for breach of contract
8. Assume a non-recourse, project finance structure

Box 5: The eight investment assumptions for solar PV in Tunisia

1. Provide scores based on the current investment environment in the country today
2. Assume you have the opportunity to invest in a 10-100 MW solar PV plant
3. Assume a high quality c-Si PV panel manufacturer with proven track record
4. Assume a build-own-operate (BOO) business model
5. Assume a comprehensive O&M contract
6. Assume that well-maintained transmission lines with free capacities are located within 10km of the project site
7. Assume an EPC construction sub-contract with high penalties for breach of contract
8. Assume a non-recourse, project finance structure

- Equity investors in renewable energy typically have greater exposure to development risks. The modelling uses the full set of 9 risk categories for equity investors. The 'permits risk' and 'financing risk' categories are removed for debt investors, assuming that banks will have prerequisites, such as having licences and equity financing in place, before considering a funding request. As such, the modelling uses 7 risk categories for debt investors.

- The modelling selects Germany as the example of a best-in-class investment environment for wind energy and solar PV. Germany is generally considered by international investors to have a very well designed and implemented policy and regulatory regime, with minimal risk for all nine of the investment risk categories. In this way, Germany serves as the baseline – the left-most column of the financing cost waterfall.

A.2. Stage 2 – Public Instruments

Public Instrument Table

The public instrument table for wind energy and solar PV is derived from the generic table in the original DREI report (Section 2.2.1). The table is set out in full in Table 3.

In order to keep the scope of the modelling manageable, the set of policy derisking instruments for fossil-fuel subsidy reform (part of 'power market risk') is excluded from the modelling.

Individual instruments in the public instrument table were then selected for Tunisia in a comprehensive manner: if the financing cost waterfall identified incremental financing costs for a particular risk category, then the matching public instrument in the table was deployed and modelled.

Policy Derisking Instruments

The following is a summary of the key approaches taken:

- **Public Cost.** Estimates for the public cost of policy derisking instruments are calculated based on bottom-up modelling. This follows the approach for costing set out in the original DREI report (Section 2.2.2). Each instrument has been modelled in terms of the costs of: (i) full-time employees and (ii) external consultancies/services. Typically, full-time employees are modelled for the operation of an instrument (e.g. the full-time employees required to staff an energy regulator), and external consultancies/services are modelled for activities such as the design and evaluation of the instrument, as well as certain services such as publicity/awareness campaigns. Policy derisking measures are modelled for the 17-year period from 2014 to 2030. Data have been obtained from analyses of Tunisian government budgets, the budgets of development agency activities in Tunisia, as well as UNDP's in-house experience. See Tables 7 and 8 for the cost estimates of policy derisking instruments.

- **Effectiveness.** Estimates for the effectiveness of policy derisking instruments in reducing financing costs are based on the structured interviews with investors, and then further adjusted to reflect UNDP's in-house experience. The assumptions for the final effectiveness (after 17 years, to 2030) are shown in Table 9. As certain policy derisking instruments may take time to become maximally effective, a linear ("straight-line") approach to time effects is modelled over the 17-year target investment period (to 2030) – this is referred to as the discount for time effects in the table.

Table 9: The modelling assumptions for policy derisking instruments' effectiveness

RISK CATEGORY	POLICY DERISKING INSTRUMENT	EFFECTIVENESS	DISCOUNT FOR TIME EFFECT	COMMENT
Energy Market Risk	Long-term targets; regulatory framework; standardised PPA; independent regulator.	75%	50%	Interview responses: high effectiveness.
Permits Risk	Streamlined process for permits; establish a dedicated one-stop shop for RE permits; contract enforcement and recourse mechanisms.	50%	50%	Interview responses: moderate effectiveness.
Social Acceptance Risk	Awareness-raising campaigns targeting general public; pilot models for community involvement at project sites.	50%	50%	Interview responses: moderate effectiveness.
Resource & Technology Risk	Resource assessment; technology and O&M assistance.	25%	50%	Interview responses: moderate/low effectiveness.
Grid/ Transmission Risk	Grid code; grid management studies.	50%	50%	Interview responses: moderate effectiveness.
Counterparty Risk	Strengthening utility's management & operational performance for existing operations.	50%	50%	Interview responses: high effectiveness.
Financial Sector Risk	Financial sector reform; strengthening investors' familiarity and assessment capacity for renewable energy.	25%	50%	Interview responses: moderate/low effectiveness.

Financial Derisking Instruments

The modelling assumptions for financial derisking instruments are informed by UNDP's in-house experience, interviews with representatives from international financial institutions and interviews with project developers.

Empirically, the selection, pricing and costing of financial derisking instruments for a particular renewable energy investment are determined on a case-by-case basis, and reflect the particular risk-return characteristics of that investment. The modelling assumptions instead cover the aggregate investments for Tunisia's 2030 wind target and represent a simplified, but plausible, formulation for the selection and pricing of financial derisking instruments. The following is a summary of the key assumptions used.

- **Cost.** Estimates of public cost of financial derisking instruments are set out in Table Table 10 below.

Table 10: The modelling assumptions on costing of financial derisking instruments

RISK CATEGORY	FINANCIAL DERISKING INSTRUMENT	DESCRIPTION OF MODELLING ASSUMPTIONS
Grid/ Transmission Risk	Take-or-Pay Clause in PPA[34]	• Assumes 2% of annual production is lost due to grid management (curtailment) or transmission failures (black-out/brown-out) • Assumes 50% of IPP's lost revenues due to grid management or transmission failures are reimbursed by take-or-pay clause
Counterparty Risk	Government Guarantee	• Assumes Tunisian Ministry of Economics and Finance provides "Letter of Support" for each PPA entered into between IPP and STEG • Simplifying assumption that no cost is attributed to the Ministry of Economics and Finance's letter
Financial Sector Risk	Public Loan	• Assumes illustrative, concessional USD/EUR loans of 4% and 20-year tenor from multilateral development banks to cover 50% of total debt needs. This is to address possible lack of capital in the Tunisian domestic financial sector. • Public cost: o Assumes the public cost is 100% of the loan amount to the IPP o Assumes 3.5x paid-in-capital multiplier, recognising that multilateral development banks can issue debt on capital markets, thereby leveraging their paid in capital (UN, 2010)
Currency/ Macroeconomic Risk	Foreign Currency Partial Indexing of PPA[35]	• Assumes illustrative mechanism whereby IPPs can request partial indexing of TND-denominated PPA tariffs to EUR. • Assumes illustrative 50% of TND-denominated PPA tariff is indexed. • Assumes 4% annual depreciation of TND vs EUR, based on historical currency exchange rates.

[34] A "take or pay" clause is a clause found in the PPA that essentially allocates risk between parties in the scenario where transmission line failures or curtailment (required by the grid operator) result in the IPP being unable to deliver electricity generated by its renewable energy plant.

[35] Partial indexing involves tariffs in a local-currency denominated PPA being partially indexed to foreign hard currencies, such as EUR or USD. In this way, IPPs are partially protected against currency fluctuations. If a PPA tender process is used, IPPs can be asked to specify the maximum degree of partial indexing they require, thereby minimising the cost to the public sector.

- **Effectiveness.** Estimates for the effectiveness of financial derisking instruments in reducing financing costs are based on the structured interviews with investors, and then further adjusted to reflect UNDP's in-house experience. The figures for effectiveness have full and immediate impact once the instrument is implemented (i.e. no timing discount). The assumptions for effectiveness are shown in Table 11.

Table 11: The modeling assumptions for financial derisking instruments' effectiveness

RISK CATEGORY	POLICY DERISKING INSTRUMENT	EFFECTIVENESS	DISCOUNT FOR TIME EFFECT	COMMENT
Grid/ Transmission Risk	Take-or-Pay Clause in PPA	25%	0%	Interview responses: high effectiveness. However, residual risks remain.
Counterparty Risk	Government Guarantee	25%	0%	Interview responses: moderate effectiveness.
Financial Sector Risk	Public Loan	0% [Impact via concessional interest rates]	50%	Interview responses: high effectiveness.
Currency/ Macroeconomic Risk	Foreign Currency Partial Indexing of PPA	50%	0%	Interview responses: high effectiveness. However, residual risks remain.

A.3. Stage 3 – Levelised Costs

Levelised Cost of Electricity (LCOE) Calculation

The DREI report's financial tool is used for the LCOE calculations. The financial tool is based on the equity-share based approach to LCOEs, which is also used by ECN and NREL (IEA, 2011; NREL, 2011). Box 6 sets out the LCOE formula used. In this approach, a capital structure (debt and equity) is determined for the investment, and the cost of equity is used to discount the energy cash-flows.

Box 6: The modelling exercise's LCOE formula

$$\frac{\%\ \text{Equity Capital} * \text{Total Investment} + \sum_{\tau=1}^{T} \frac{(\mathit{O\&M\ Expense})_\tau + (\mathit{Debt\ Financing\ Costs})_\tau - \mathit{Tax\ Rate} * (\mathit{Interest\ Expense}_\tau + \text{Depreciation}_\tau + \mathit{O\&M\ Expense}_\tau)}{(1 + \mathit{Cost\ of}\ \text{Equity})^\tau}}{\sum_{\tau=1}^{T} \frac{\mathit{Electricity\ Production}_\tau * (1 - \mathit{Tax\ Rate})}{(1 + \mathit{Cost\ of}\ \text{Equity})^\tau}}$$

Where,
% Equity Capital = portion of the investment funded by equity investors
O&M Expense = operations and maintenance expenses
Debt Financing Costs = interest & principal payments on debt
Depreciation = depreciation on fixed assets
Cost of Equity = after-tax target equity IRR

Tax-deductible, linear depreciation of 95% of fixed assets over the lifetime of investment is used. The standard corporate tax rate for Tunisia at 30% was used (Deloitte, 2012). No tax credits, or other tax treatment, are assumed.

Baseline Energy Mix Levelised Costs and Emissions

The modelling makes a number of important methodological choices and assumptions regarding the baseline. The key steps in the approach taken are set out here:

- A marginal baseline (build margin) approach is used on the basis that Tunisia is characterised by rapidly increasing energy demand and, as such, new wind energy and solar PV installations will likely not replace existing capacity.

- In addition, a private sector perspective to baseline investment is used and as such private sector financing costs are modelled. This reflects the fact that Tunisia is seeking to attract private-sector investment irrespective of energy technology, and allows for the comparability of the marginal baseline LCOE (private sector) with the wind energy and solar PV LCOEs (also private sector).

- To date in Tunisia, historical private sector IPP investment has been in combined cycle gas turbine (CCGT) technology, with two such IPPs to date. As such, the modelling uses combined cycle gas turbine technology as the marginal baseline technology.

- The modelling assumptions for CCGT are shown below in Table 12.

Table 12: The modelling assumptions for the baseline energy technology, combined cycle gas turbine (CCGT)

TECHNOLOGY ITEM	ASSUMPTION	SOURCE
Initial investment cost (EUR/MW_{el})	700,000	Schmidt *et al.* (2012)
O&M cost excl. fuel (EUR/MW_{el})	27,100	Schmidt *et al.* (2012)
Lifespan (years)	25	Schmidt *et al.* (2012)
System Efficiency	52.7%	Tunisia Energy Mix Study (ANME, 2013)
Capacity Factor	79.9%	Tunisia Energy Mix Study (ANME, 2013)
Emissions Factor	0.448 tCO_2e/MWh	Bizerte CDM PDD (2012)

- Private-sector financing costs are used to calculate the LCOE of the marginal baseline mix. The cost of equity and cost of debt used for CCGT were those obtained for wind and solar energy (BAU scenario) in Tunisia, discounted by 15% to account for the existing track record of CCGT compared to wind energy. Loan tenors were taken as half the lifetime of the particular generation technology.

- Current fuel prices were taken as the starting point and then grown over time using the IEA medium-term price projections (WEO, 2013). The current prices were taken from STEG's transfer prices for IPPs (www.steg.com.tn/fr/clients_ind/tarifs_hp.html) as of May 2014. This generates a price of EUR 20.27/MWhth in 2014, with a linear increase over the 25-year lifetime of the plant to EUR 34.74/MWhth in 2039. Recently, there have been efforts by STEG to reduce subsidies on fuel costs; however, it is not clear to what degree these STEG transfer prices are subsidised. It is noted that the current STEG transfer price is close to the current European spot price for natural gas. The issue of subsidies can be an area of further research in future applications of this methodology in Tunisia.

- Emissions data for CCGT is taken from the latest registered UNFCCC CDM PDD in Tunisia.[36]

Wind Energy - Levelised Costs

The assumptions for the wind energy LCOE calculation are set out in Table 13 below.

Table 13: The modelling assumptions for wind energy technology specifications

TECHNOLOGY ITEM	ASSUMPTION	SOURCE
2030 wind energy installed capacity	1,404 MW	Tunisian Solar Plan (ANME, 2012) Note: The TSP's 1,755 MW figure is adjusted to reflect 80% private sector investment
Wind energy capacity factor	30.0%	Authors. Tunisian Solar Plan (ANME, 2012) assumes 28.2%
Turbine size	2-3 MW class	Authors
Park size	50-100 MW	Authors
Core investment costs, including balance of plant costs (civil works, transformers) **2014 Cost**	1,307,692 EUR/MW	Tunisian project developers
Annual O&M costs **At start of operation** **Annual increase**	13,836 EUR/MW 2%	Tunisian project developers
Lifetime	20 years	Authors

[36] Bizerte wind farm CDM PDD (2012). Availabe at https://cdm.unfccc.int/Projects/DB/DNV-CUK1337768970.01/view

Solar PV - Levelised Costs

The assumptions for the solar PV LCOE calculation are set out in Table 14 below.

Table 14: The modelling assumptions for solar PV technology specifications

TECHNOLOGY ITEM	ASSUMPTION	SOURCE
2030 solar PV installed capacity	736 MW	Tunisian Solar Plan (ANME, 2012) Note: The Plan's 1,510 MW figure is adjusted to reflect (i) distributed solar PV of 590 MW by 2030 and (ii) 80% private sector investment
Solar PV capacity factor	21.8%	Authors. Tunisian Solar Plan (ANME, 2012) assumes 21.8%
Solar PV technology	C-Si	Authors
Park size	10-100 MW	Authors
Core investment costs, including balance of plant costs (civil works, transformers) **2014 Cost**	1,253,846 EUR/MW	Bloomberg New Energy Finance (2014)
Annual O&M costs **At start of operation** **Annual increase**	19,231 EUR/MW 2%	Tunisian project developers
Lifetime	20 years	Authors

Wind Energy and Solar PV Grid Interconnection Costs

Grid interconnection costs are also included in the LCOE for wind energy and solar PV. The modelling assumes that all wind energy and solar PV plants are within 10 km of the power grid.

The assumptions used for grid interconnection costs are set out in Table 15 below.

Table 15: The modelling assumptions for wind energy and solar PV grid interconnection costs

TECHNOLOGY ITEM	ASSUMPTION	SOURCE
Cost per km of Individual 90kV Transmission Line	EUR 150,000	Tunisian project developers
Number of Transmission Lines (Redundancy)	2	Authors
Typical length of Transmission Line	10km	Authors
Typical size of wind energy or solar PV plant	75 MW	Authors
Cost of Sub-Station	EUR 3,000,000	Tunisian project developers

A.4. Stage 4 – Evaluation

Wind Energy and Solar PV Sensitivities

The modelling performs a number of sensitivities for wind energy and solar PV.

Table 16 below sets out the assumptions and sources used for the sensitivities to investment costs, capacity factor, fuel costs and financing costs.

Table 16: The modelling approach to sensitivities for wind energy and solar PV

TECHNOLOGY ITEM	ASSUMPTION	SOURCE
Investment Costs	Wind energy: Base case (2014 cost): EUR 1.241 million/MW Sensitivity (2022 cost): EUR 1.117 million/MW Solar PV: Base case (2014 cost): EUR 1.190 million/MW Sensitivity (2022 cost): EUR 1.010 million/MW	Authors, informed by literature review, including Schmidt *et al.* (2013) and IRENA (2012b, 2012c). The reduction for wind energy amounts to 10% between 2014 and 2022. The reduction for solar PV amounts to 15% between 2014 and 2022. 2022 is selected as this reflects the mid-point of the 2014-2030 modelling period.
Capacity Factor	Wind energy: Base case: 30% Sensitivity: 35%	Authors, informed by consistent feedback from project developers indicating that the official figure used in the base case (30%) was overly conservative.
Fuel Costs	Wind energy and solar PV: +/- 20% difference to IEA fuel cost forecasts	Authors
Financing Costs	Wind energy and solar PV: +/- 1% point difference on financing costs from interviews	Authors

The approach to modelling the sensitivity to balancing costs was informed by two papers by the American Tradition Institute (Taylor, 2012) and the Mauritius utility (CEB, 2014). It is assumed that balancing can be provided by Tunisia's combined cycle gas turbine (CCGT) plants, with ramping provided by using the plants in single-cycle gas turbine mode. The approach models two distinct components of balancing costs: (i) capital recovery costs, reflecting the cost of capital of having balancing plants laying idle on standby; and (ii) fuel costs, reflecting higher fuel costs for balancing plants, due to the balancing plants being less efficient due to lower usage. Table 17 below sets out the assumptions and sources used.

Table 17: The modelling approach for balancing costs for wind energy and solar PV

COMPONENT	ASSUMPTION	SOURCE
Capital Recovery Costs	Wind energy: Capacity factor: 30% Capacity value: 7.5% This results in 75 MW of balancing gas plants being required for every 100 MW of wind energy installed	Source for capacity factor: base case model Source for capacity value: (Taylor, 2012)
	Solar PV: Capacity factor: 21.8% Capacity value: 15.0% This results in 31 MW of balancing gas plants being required for every 100 MW of solar PV installed.	Source for capacity factor: base case model Source for capacity value: Authors, based on an analysis of the electricity demand curve for Tunisia, which peaks at lunch time and early afternoon.
Fuel Costs	Wind energy and Solar PV: Base case efficiency of CCGT plant: 52.7% Lower efficiency for single cycle model: 34.5% Load factor for CCGT plant when used to balance wind energy and solar PV: 15.0%	Source: STEG Source: (Taylor, 2012) for wind energy.

ANNEX B: REFERENCES

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