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LEBANON:

DERISKING RENEWABLE ENERGY INVESTMENT 2025

SELECTING PUBLIC INSTRUMENTS TO PROMOTE RENEWABLE ENERGY INVESTMENT FOR THE LEBANESE NATIONAL RENEWABLE ENERGY ACTION PLAN

LEBANON 2025

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Disclaimer

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Annex A: Methodology and Data

Acronyms

BAU	Business as usual
BDL	Banque du Liban
BOO	Build-Own-Operate
CCGT	Combined Cycle Gas Turbine
CDM	Clean Development Mechanism
CoD	Cost of Debt
CoE	Cost of Equity
CNRS	National Council for Scientific Research
CSP	Concentrated Solar Power
DREI	Derisking Renewable Energy Investment
EDL	Électricité du Liban
EDZ	Électricité de Zahlé
EIA	Energy Information Administration (US)
EPC	Engineering, Procurement and Construction
ERA	Electricity Regulatory Authority
EUR	Euro
FiT	Feed-in-tariff
FTE	Full-time Employee
GDP	Gross Domestic Product
GEF	Global Environment Facility
GoL	Government of Lebanon
IEA	International Energy Agency
INDC	Intended Nationally Determined Contribution
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
kW	Kilowatt
kWh	Kilowatt-hour
LCEC	Lebanese Centre for Energy Conservation
LCOE	Levelized Cost of Electricity
LEEREFF	Lebanon Energy Efficiency & Renewable Energy Finance Facility
MoE	Ministry of the Environment
MoEW	Ministry of Energy and Water

MRV	Monitoring, Reporting and Verification
MW	Megawatt
MWh	Megawatt-hour
NA	Not Applicable/Available
NDC	Nationally Determined Contribution
NAMA	Nationally Appropriate Mitigation Action
NEEREA	National Energy Efficiency and Renewable Energy Action
NERA	National Electricity Regulatory Authority
NREAP	National Renewable Energy Action Plan 2016-2020
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
RFP	Request For Proposal
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
VAT	Value-Added Tax

Foreword

Ministry of Energy and Water

The Ministry of Energy and Water is actively advancing the adoption of sustainable energy and driving Lebanon's green energy transition. In 2025, the Ministry outlined its renewable energy ambitions for 2030 through the *Nationally Determined Contributions 3.0 (NDC)* under the Paris Climate Agreement, in addition to the *National Renewable Energy Action Plan (2025–2030)*. These initiatives serve as a roadmap for the country's renewable energy development in the years to come.

As part of its strategy, the Ministry envisions that large-scale renewable energy projects will be financed through private investments and public–private partnerships, facilitated by a supportive legal and regulatory framework. To achieve this, conducting a *Derisking Renewable Energy Investment (DREI)* analysis was critical for identifying and addressing regulatory barriers and investment risks. Mitigating these challenges is essential to reducing financing costs and encouraging greater private sector involvement. A combination of public policy instruments will play a pivotal role in deploying renewable energy resources cost-effectively.

This report marks another significant step toward building a favorable investment climate for Lebanon's renewable energy sector. It establishes a comprehensive framework for identifying barriers and associated risks while presenting tailored public intervention strategies to address, mitigate, or manage these challenges. Additionally, the report includes a decision-support tool designed to enhance the penetration of renewable energy technologies by creating a more attractive and enabling environment for investments.

By progressively implementing derisking measures, the Ministry of Energy and Water with the support of other public stakeholders aims to achieve a balanced risk-return profile that facilitates large-scale private investments. Ultimately, the objective is to deliver reliable, affordable, and sustainable renewable energy solutions, bringing Lebanon closer to its 2030 emission reduction targets while supporting its transition to a green energy future.

H.E. Joe Saddi

Minister of Energy and Water

Foreword

European Union

A functioning, transparent, affordable and sustainable electricity supply is key to Lebanon's socioeconomic recovery.

Lebanon's substantial renewable energy potential offers a viable path toward strengthened energy security, reduced public sector burden, and mid-term perspectives for a gradual return to economic growth. Achieving this vision requires not only a solid understanding of current investment barriers, but also the institutional setup and tools necessary to derisk and mobilise capital.

The European Union has long been a committed partner of Lebanon in this sector. Through the **CEDRO V project**, the EU supports innovation, technology transfer, and the development of clean-energy start-ups. We are also providing significant assistance to **solarise public institutions**, including the Lebanese Armed Forces, the Internal Security Forces, and the justice and education sectors—through a **EUR 22 million programme implemented with UNDP**. In the private sector, the EU has partnered with KfW on an **EUR 11 million initiative** to improve access to finance for green investments by MSMEs through microfinance institutions.

A crucial institutional milestone has also recently been achieved by the Government, with the creation of the **Electricity Regulatory Authority (ERA)**. Establishing an independent, transparent regulator is essential for a functioning electricity system. ERA plays a central role in operationalising the Distributed Renewable Energy Law (2023/318) and in enabling investment in **power-purchase agreements (PPAs)**—a cornerstone for scaling private-sector participation in renewable energy generation.

Looking ahead, the European Union is working closely with development banks to activate its investment toolbox—most notably the European Fund for Sustainable Development Plus **(EFSD+)**—including guarantee mechanims that derisk the business environment, by partially covering investments from development banks and other co-investors in private sector–led renewable energy projects.

This *Derisking Renewable Energy Investment Study* provides a solid analytical basis for these efforts in upgrading the energy sector in Lebanon, by identifying targeted derisking measures and a coherent framework for action. The European Union remains committed to supporting Lebanon in building a cleaner, more reliable, and more sustainable energy future.

Sandra De Waele

EU Ambassador to Lebanon

Foreword

Netherlands Enterprise Agency

Lebanon is facing profound challenges in its energy sector. Amid prolonged electricity shortages and economic pressures, families and private businesses continue to show remarkable resilience and determination. In this context, the shift toward sustainable and affordable renewable energy is more than merely a technical transition; it is an opportunity to strengthen stability, restore confidence, and foster new avenues for growth.

The Kingdom of the Netherlands is honored to have partnered in the preparation of this study, *Derisking Renewable Energy Investment in Lebanon.* As a nation that has set ambitious goals to accelerate renewable energy at home and abroad, we strongly believe in the global responsibility to support a just and inclusive energy transition. Climate action does not stop at national borders, it requires shared solutions and shared investment in a more secure and sustainable future for all.

Lebanon has tremendous potential in its natural resources, especially in its solar energy. Unlocking this potential, however, will require a supportive environment built on transparency, trust, and sound governance. This report highlights that by strengthening enabling policies and reducing uncertainty for investors, Lebanon can attract the international expertise and finance needed to realize its clean energy ambitions.

Renewable energy offers Lebanon a pathway to reduced reliance on imported fuels, to cleaner air, to more resilient power systems, and most importantly, to hope. With political will and effective partnership, these benefits can become a reality for every Lebanese household and community.

The Netherlands remains committed to working closely with Lebanon and its partners, standing alongside those who are striving to build a sustainable future. We hope this report will contribute meaningfully to dialogue and decisions in the near future, and that it will serve as a stepping stone toward lasting progress.

A cleaner and brighter energy future for Lebanon is within reach. Together, we can help make it happen.

Frank Mollen

Kingdom of The Netherlands Ambassador to Lebanon

Foreword

United Nations Development Programme

Lebanon stands at a critical juncture in its energy transition. Decades of structural challenges in the electricity sector, compounded by recent crises and conflict, have underscored the urgency of reform. Yet these challenges also present an opportunity: to rebuild a power system that is reliable, afordable, and sustainable.

This updated Derisking Renewable Energy Investment (DREI) report provides a clear roadmap for unlocking private sector investment in renewable energy. It demonstrates that Lebanon's wind, solar, and hydro resources are not only abundant but economically competitive, even under current conditions. By addressing key investment risks through targeted public measures, Lebanon can significantly reduce financing costs, lower electricity prices, and catalyze billions in private investment.

The numbers speak for themselves. The public investment measures outlined in the study would come at a total cost of USD 191 million to the Government, though have the potential to attract USD 743 million in private capital (nearly a four-fold leverage ratio), significantly boosting investment in Lebanon's renewable energy sector. Additionally, the measures proposed in the study could increase the cost savings of Lebanon's electricity bill to a total of USD 1.7 billion over the lifetime of the renewable energy assets, reduce CO_2 emissions by 1.13 million tonnes annually, improve air quality, and strengthen energy security, all while lowering electricity costs for consumers.

Beyond cost advantages, this approach strengthens energy security, reduces dependence on imported fuels, improves air quality and accelerates Lebanon's progress toward its climate commitments under the Paris Agreement.

The United Nations Development Programme remains committed to supporting the Government of Lebanon and its partners in this endeavor: to transform Lebanon's energy sector into a driver of resilience and sustainable growth, ensuring clean and affordable electricity to the Lebanese population.

Blerta Aliko

UNDP Resident Representative

KEY POINTS FOR DECISION-MAKERS

Key Points For Decision-Makers[1]

The objective of this report is to analyze the most cost-effective public derisking measures to promote private sector investment in large-scale wind energy, solar PV, and hydro run-of-river projects in Lebanon. In addition to utility-scale solutions, the report also evaluates a decentralized model (with battery storage and without storage), specifically analyzing mini-grids. The findings are based on results from a quantitative, investment-risk-informed modeling analysis, with data sourced from structured interviews with private sector investors and developers.

Context and Opportunity for Renewable Energy

Lebanon's power sector is currently characterized by a significant supply-demand imbalance, high generation costs and a lack of financial sustainability. Électricité du Liban (EDL) has a total installed design capacity of 2,651 megawatts (MW). This figure includes all power generation sources under its control, such as hydropower plants and independent power producers (IPPs). However, due to aging infrastructure, maintenance issues, and operational inefficiencies, the actual available (or derated) capacity is significantly lower—around 1,895 MW. This is the amount of electricity EDL can realistically produce and deliver under current conditions. In contrast, electricity demand during peak summer months—when air conditioning and cooling systems are heavily used—can reach up to 3,844 megawatts peak (MWp) prior 2019 crisis. This means that EDL's available supply falls short of peak demand by nearly 1,950 MW, leading to widespread electricity shortages and scheduled power cuts. This current installed capacity is almost entirely powered by fuel oil, a relatively expensive source of power with only 282 MW of hydro power installed. Prior to 2022, EDL's end-user tariffs were not cost reflective, requiring a large annual subsidy, estimated at close to USD 2 billion annually. The economic deterioration in Lebanon since 2019 and the war in November 2024 was followed by a similar worsening of the electricity sector, with EDL unable to maintain even a few hours of electricity supply from the national utility grid.

Renewable energy holds strong potential in Lebanon. This report uses the 2030 investment targets for Lebanon of 226 MW in wind energy[2], 330 MW in solar PV[3], 58.4 MW of additional hydro power and 1,200 MW of additional distributed solar PV[4]. These targets are based on the permits issued for wind energy and utility solar PV, while the hydro target is based on 2021 Least Cost of Energy Plan[5]. Lebanon is well positioned for investment, with good renewable energy resources and potential dynamic domestic business and financial sector. Renewable energy has the opportunity to contribute positively to Lebanon's power sectors, increasing the reliability of the power supply, decreasing the country's dependence on fuel imports, improving the affordability of the energy mix, and reducing the need for subsidies to EDL.

1 This 'Key points for decision-makers' section summarizes the findings of the report in a succinct manner. As such, references have not been included in this section but are found later in the relevant sections of the full report.

2 The 226 MW wind energy target is not expected to be realized by 2030. Nevertheless, it has been incorporated as a hypothetical benchmark within the scope of this DREI modeling exercise.

3 The 330 MW is divided between the 180 MW issued by the government and 150 MW loans by the World Bank (July 2025).

4 For the de-risking of distributed solar PV, we will consider 2 scenarios, 1,200 MW with storage and 1,200 MW without storage.

5 The hydropower projects totaling 58 MW are considered hypothetical, as there are currently no expectations for their completion by 2030. However, for the purposes of this study, it is assumed that the 2030 targets will be achieved, and the projects are included in the modeling exercise.

Renewable energy can also support Lebanon's voluntary contributions to climate change mitigation under the UNFCCC.

Financing Costs and Risk Environment

The modelling performs a detailed analysis of the financing costs and risk environment for wind energy, solar PV (utility and distributed) and hydro power in Lebanon today.

Financing costs (the cost of equity and the cost of debt) for wind energy, solar PV and hydro power projects are high in Lebanon. For instance, the present study finds that the cost of equity[6] for large-scale wind energy, solar PV and hydro power in Lebanon today is 26.0%, compared with 8.0% in Germany and 15% in Jordan[7].

These higher financing costs reflect a range of investment risks for wind energy, utility and distributed solar PV and hydro power projects in Lebanon. Five risk categories were found to contribute most to higher financing costs[8]:

1. "Permits risk" that concerns the regulatory and administrative procedures required to obtain construction and operational permits, including delays, unclear requirements, or changes in permitting frameworks and ERA;
2. "Grid/transmission risk" that concerns the reliability of the grid and transmission;
3. "Counterparty risk" that concerns the reliability of the electricity buyer;
4. "Political risk" that concerns the overall stability and peace;
5. "Currency risk" that concerns fluctuations in exchange rates between the local currency and foreign currencies used in financing or revenue.

Public Derisking Measures

For each wind energy, utility and distributed solar PV and hydro power, the modelling examines the selection and cost-effectiveness of public derisking measures to meet the 2030 investment targets. Public derisking measures can be understood as interventions by the government and its partners that address specific investment risks, in the form of policies, programs or financial products.

For wind energy (2030 investment target: 226 MW) the modelling identifies a targeted package of public derisking measures with an estimated cost of USD 91.3 million until 2030. These derisking measures result in the following benefits:

- Catalysing USD 380 million in private sector investment in wind energy.
- Lowering wind energy generation costs due to derisking from USD 15.1 cents to USD 10.0 cents per kWh.

6 USD-denominated cost of equity.

7 Jordan CoE only considers wind and solar PV projects.

8 The risks are considered for both model of Germany and Jordan. Moreover, some additional risks are very close contributors to financing costs like financial risks. For this exercise we will consider grid/transmission risk as reference to investors feedback.

- Creating economic savings related to derisking of wind energy of USD 230 million over 20 years[9].
- Reducing carbon emissions by 10.6 million tonnes of CO_2 over 20 years, relative to the baseline.

For solar PV (2030 investment target: 330 MW) the modelling identifies a targeted set of public derisking measures with an estimated cost of USD 71.5 million until 2030. When implemented, this results in the following benefits:

- Catalysing USD 247.5 million in private sector investment in solar PV.
- Lowering solar PV generation costs due to derisking from USD 10.3 cents to USD 8.3 cents per kWh.
- Creating economic savings related to derisking of solar PV of USD 83 million over 20 years.
- Reducing carbon emissions by 7.9 million tonnes of CO_2 over 20 years, relative to the baseline.

For hydro power (run-of-river) (2030 investment target: 58 MW), the modelling identifies a targeted set of public derisking measures with an estimated cost of USD 28 million until 2030. When implemented, this results in the following benefits:

- Catalysing USD 114 million in private sector investment in hydro power plants.
- Lowering hydropower generation costs due to derisking from USD 6.2 cents to USD 4.3 cents per kWh.
- Creating additional economic savings related to derisking of hydro power of USD 43 million over 50 years.
- Reducing carbon emissions by 10.3 million tonnes of CO_2 over 50 years, relative to the baseline.

For distributed solar PV with battery storage (2030 investment target: 1,200 MW), the modelling identifies a targeted set of public derisking measures with an estimated cost of USD 86.6 million until 2030. When implemented, this results in the following benefits:

- Catalysing USD 1.035 billion in private sector investment in solar PV and battery storage.
- Lowering solar PV generation costs due to derisking from USD 24.7 cents to USD 17.3 cents per kWh.
- Creating economic-wide savings related to derisking of solar PV of USD 547 million over 20 years.
- Reducing carbon emissions by 15.02 million tonnes of CO_2 over 20 years, relative to the baseline.

For distributed solar PV without battery storage (2030 investment target: 1,200 MW), the modelling identifies a targeted set of public derisking measures with an estimated cost of USD 43.2 million until 2030. When implemented, this results in the following benefits:

- Catalysing USD 513 million in private sector investment in solar PV.
- Lowering solar PV generation costs due to derisking from USD 22.4 cents to USD 14.9 cents per kWh[10].

9 The savings figures quoted reflect the direct economic benefits from public derisking measures, i.e., the aggregate difference in lower generation costs (negative price premium) and the derisking cost over the lifetime of the asset. The savings figures do not include the indirect benefits accruing from a lower need for subsidization of tariffs due to renewable energy's entry into the power market as a whole.

10 The solar PV generation cost for the mini-grid system without storage is lower than the solar PV generation with storage due to the absence of investment in lithium batteries.

- Creating economic savings related to derisking of solar PV of USD 293 million over 20 years.
- Reducing carbon emissions by 5.9 million tonnes of CO_2 over 20 years, relative to the baseline.

Conclusion

Today's investment environment for renewable energy in Lebanon reflects a number of risks, leading to high financing costs and elevated generation costs. The report's methodology identifies specific public derisking measures that directly address these risks—lowering the cost of capital and ultimately reducing electricity generation costs.

The modelling demonstrates how investing in public derisking measures can unlock substantial economic benefits in meeting the targets of Lebanon's Nationally Determined Contributions. In fact, in several scenarios, renewable energy technologies already outperform the existing fossil-based baseline, even before applying derisking measures. This results, for example in negative abatement costs, highlighting how renewables are not just cleaner but also cheaper than the status quo. Beyond the financial benefits for consumers, the implementation of policy and financial instruments has the potential to unlock international investment opportunities in Lebanon's renewable energy sector. By reducing risk and improving market confidence, these instruments help create a more secure and attractive environment for investors.

The opportunity for policy-makers in Lebanon is clear: by implementing targeted public derisking measures, Lebanon can accelerate clean energy investments while saving public funds. The result is more affordable, reliable, and sustainable power for all Lebanese citizens.

EXECUTIVE SUMMARY

Executive Summary

Introduction

As of July 2025, a new government has been established recently and remains active, presently engaged in the process of formulating updated renewable energy targets for the coming years. Notwithstanding these ongoing developments, the Ministry of Energy and Water has maintained a consistent position, reiterating its commitment to advancing the implementation of already issued permits[11] for solar projects, with the objective of commissioning these installations by 2030 with an additional 1,200 MW of distributed solar PV, subject to feasibility. Regarding wind energy, three permits have been issued with a combined capacity of 226 MW. However, these projects are not expected to become operational before 2030. For the purposes of this analysis, this entire capacity will be included in the modeling and presented accordingly.

Amid the country's gradual recovery and stabilization following the 2024 conflict, economic growth remains modest yet positive. Projections estimate that Lebanon's GDP will grow by approximately 4% annually through 2030, reflecting a cautious optimism as the nation regains its footing. Correspondingly, electricity demand is expected to increase, with forecasts suggesting it will reach 21,856 GWh by 2030.

By systematically assessing the impact of investment risks alongside a menu of public derisking measures, this study aims at contributing to an enabled environment for large-scale renewable energy investments. The focus is set on onshore wind, solar PV energy, hydro run-of-river projects, and the distributed (mini-grid) solar PV, the four key technologies for achieving the Nationally Determined Contributions.

Context and Opportunity for Renewable Energy in Lebanon

Lebanon's power sector is characterised by a significant supply-demand imbalance, high generation costs and a lack of financial sustainability. This situation has persisted for the better part of the past 30 years since the end of the Lebanese civil war in the early 1990s. Électricté du Liban (EDL), the national utility, has an installed capacity of 2,651 MW, but due to the relatively poor condition of its generation infrastructure, only approximately 1,900 MW capacity are available. This is far below peak demand, which can reach up to 3,844 MWp during the summer months. In addition to the sub-standard generation infrastructure, the use of costly fuel oil, heavy fuel oil and diesel, coupled with tariff levels and collection rates that cannot cover these costs, further dampen the ability of EDL to purchase fuel and deliver electricity to customers. Between 2010 and 2020, annual budgetary transfers to EDL averaged 3.8 percent of GDP.

Furthermore, technical and non-technical losses on the network are very high. EDL estimates technical transmission losses at 5.7% and around 34.7% of total power generated was not billed[12].

Renewable energy holds strong potential in Lebanon. Lebanon is well positioned for investment, with

11 Regarding renewable electricity, the permits issued in terms of total installed capacity is 226 MW onshore wind energy, ca. 180 MW solar PV plus 150 MW loans for solar PV from the world bank and ca. 58 MW hydro power (through 2021 Least Cost of Energy Plan project).

12 3RF meeting dated March 2024.

good renewable energy resources and dynamic domestic business and financial sectors. Renewable energy has the opportunity to contribute positively to Lebanon's power sector, increasing the reliability of the power supply, decreasing the country's dependence on fuel imports, improving the affordability of the energy mix, and reducing the need for subsidies to EDL. Renewable energy can also support Lebanon's contributions to climate change mitigation under the UNFCCC.

So far, there has been no investment in large-scale renewable energy (wind and solar PV) projects in Lebanon and only limited development of mini-grid systems. In the wind sector, no investments have been made. For solar PV, the only government-owned plant is the 1.1 MW Beirut River Solar Snake (BRSS). Hydro is a well-established technology with some capacity being used in Lebanon for power generation, however, the plants are outdated and needs rehabilitation.

In 2013, a procurement process for 3 wind PPAs of 20 years duration with a capacity of 226 MW was initiated (Hawa Akkar); this process has faced delays but on February 1st 2018, the PPAs were awarded for 9.6 UScent/kWh. Moreover, 12 Solar PV PPAs of 25 years duration (total capacity: 180 MW) are awarded on May 12th, 2022 for 5.7 UScent/kWh in the Bekaa and 6.27 UScent/kWh in other regions.

In 2018 the MoEW/LCEC launched an EOI for the development of hydro projects at Daraya (+13.2 MW), Chamra (+19 MW), Yamouneh (+4.7 MW), Blat (+21.5 MW)-Total hydro EOI (58.4 MW) with an additional planned hydro development on Janneh Dam (+54 MW) which was put on hold. Due to the 2019 financial crisis, this EOI did not lead to any award. For this study, only 58.4 MW will be considered for our models.

There are longstanding efforts to put in place an appropriate legal framework for large-scale renewable energy, including power sector reform. On the other hand, there have been successful efforts and schemes put in place in small-scale renewable energy which led to an approximate 1,400 MW of installed distributed solar PV of which 16-18 MW were destroyed in the 2024 war on Lebanon. Overall, as informed by interviews for this study, private sector investor interest in large-scale renewable energy is strong.

The Derisking Renewable Energy Investment Methodology

In 2013, UNDP issued the Derisking Renewable Energy Investment report, the "DREI report", (Waissbein et al., 2013) and the DREI mini-grid Report (Waissbein et al., 2018). The DREI report introduced an innovative methodology (the "DREI methodology"), with an accompanying financial tool, to quantitatively compare the cost-effectiveness of different public instruments in promoting renewable energy investment. The analysis of Lebanon set out in this report is based on the DREI methodology for both utility scale and distributed solar PV investments.

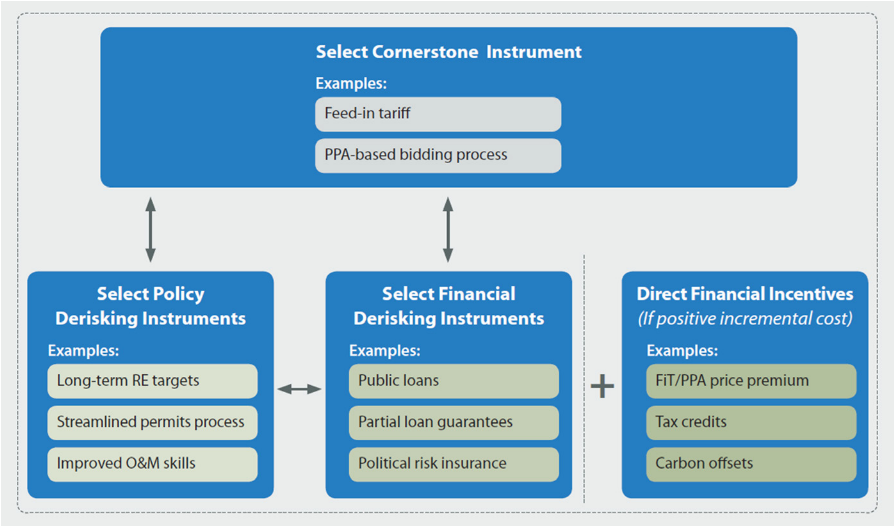
A key focus of the DREI methodology is on financing costs for renewable energy. While technology costs for renewable energy have fallen dramatically in recent years[13], private sector investors in renewable energy in developing countries still face high financing costs (both for equity and debt). These 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

13 For example, in the case of solar photovoltaics, module prices declined by around 90% over the past decade, while for onshore wind energy, installation costs fell by about 80% each time the cumulative installed capacity doubled between 1983 and 2023 (IRENA, 2024).

developing countries, require a high rate of return to compensate for these risks[14].

In seeking to create an enabled environment for private sector renewable energy investment, policy-makers typically implement a package of public instruments[15]. 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.

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



Source: Derisking Renewable Energy Investment (Waissbein et al., 2013).

The **cornerstone instrument** is the centerpiece 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:

- **Instruments that reduce risk,** by addressing the underlying barriers that are the root causes of investment risks. These instruments utilize 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

14 Indeed, as is shown later in this report, interviews with project developers identified higher financing costs for wind energy, solar PV and hydro power investment in Lebanon in comparison to Germany, a well-established market. For example, the cost of equity (USD-denominated) is estimated at 26% in Lebanon today based on the capM model, in comparison to 8% in Germany.

15 Public instruments can be understood to be domestic government interventions in the form of policies and programs. These instruments can be non-financial or financial in nature.

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”**.

- **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”**.

Modelling Results

This report, using the DREI methodology, sets out the results of modelling to select public instruments to attract private sector investment in Lebanon to meet the 2030 targets based on the permits issued by the Ministry of Energy and Water for large-scale wind energy and solar PV in addition to hydro power and distributed Solar PV.

Risk Environment

Data on the risk environment were obtained from a total of 19 interviews held with project developers, investors and loan providers who are domestically and internationally active and who are considering, or are actively involved in, large-scale wind, utility/distributed solar PV and hydro power investment opportunities in Lebanon and abroad.

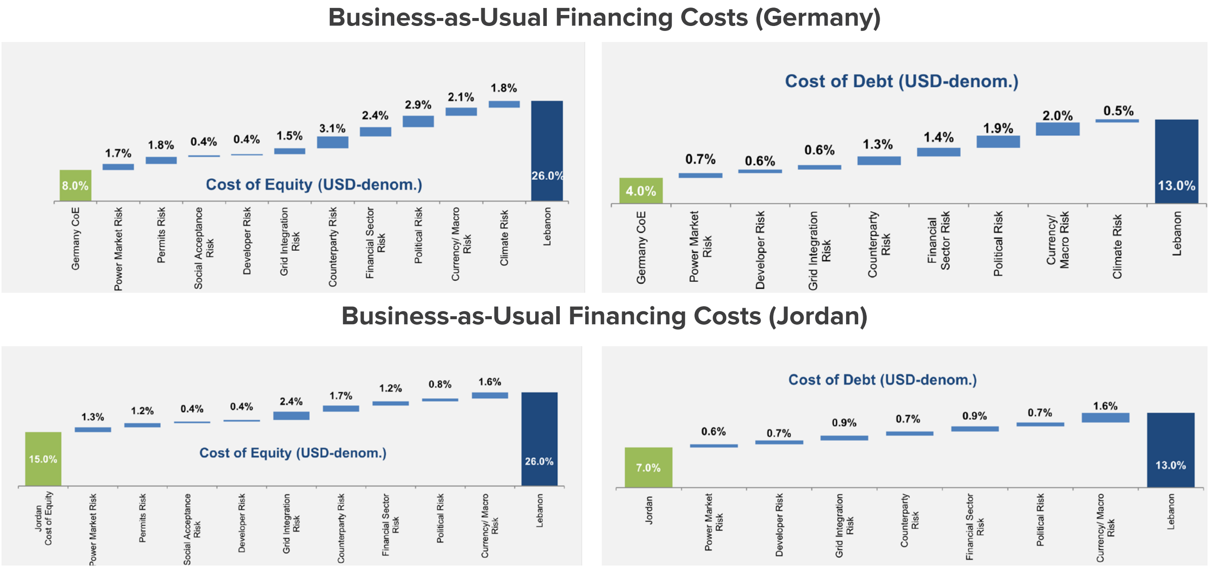
The results estimate that financing costs for wind energy, solar PV and hydro power in Lebanon today are 21.0% for the cost of equity (CoE), and 13.0% for the cost of debt (CoD)[16]. However, when applying the Capital Asset Pricing Model (CAPM), the cost of equity for Lebanon is estimated at 26%, which will be used as the basis for the financial modeling. These are substantially higher than in the best-in-class country, Germany, which are estimated at 8.0% CoE and 4.0% CoD. For additional precision, CoE and CoD were compared with Jordan, selected as best-in-region country, which are estimated 15.0% and 7.0% respectively. Jordan was selected as the best-in-region benchmark given its proven success in attracting competitive financing for renewable energy projects, supported by stable regulatory frameworks and active participation of international lenders. Given the longevity of energy assets in general as well as the capital intensity of renewable energy investments in particular, the impact of Lebanon’s higher financing costs on the competitiveness of wind energy and solar PV is significant.

Figure 2 shows how a range of investment risks currently contribute to these higher financing costs. The risk categories with the largest impact on elevated financing costs are 1) Permit risk, which relates to accessing power markets and the price paid for renewable energy, 2) financial risk that concerns the financial sector experience and capacity, 3) counterparty risk that concerns the credit-worthiness of the electricity off-taker, 4) political risk that concerns a country’s general intra- and international stability; and 5) currency risk that concerns fluctuations in exchange rates between the local currency and foreign currencies used in financing or revenue, potentially affecting project returns and financial stability.

16 USD-denominated cost of equity and debt.

While gender-responsive public instruments were initially considered during the early scoping phase of this assessment, consultations and discussions with investors and energy sector stakeholders concluded that such instruments were not directly relevant to the context of de-risking renewable energy investments in Lebanon.

Figure 2: Impact of risk categories on financing costs for wind energy, solar PV (utility and distributed) and hydro power investments in Lebanon, business-as-usual scenario[17].



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

Public Instrument Selection

The modelling uses 2030 targets for large-scale wind energy (226 MW), solar PV (330 MW), the 2021 Least Cost of Energy Plan hydro power (58 MW), and distributed solar PV (1,200 MW) based on the already existing permit for renewable energy[18]. 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 address 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 to be USD 4.3 million, and for financial derisking instruments USD 87 million[19]. For utility solar PV, the policy derisking instruments are

17 The financing cost waterfalls shown here are for Germany and Jordan, calculated by differentiating between the answers from equity and from debt investors, but not distinguishing further between investors with focus on wind energy, investors with focus on solar PV and investors focused on hydro power. It is recognized that the risk profiles of large-scale wind energy, solar PV, hydro and distributed solar PV power can differ. However, the results of the interviews with wind energy, solar PV and hydro power investors made clear that these differences are minimal in the Lebanese context. As such, the interview answers from equity and from debt investors were not further split into 'wind energy focus', 'solar PV focus' and hydro power sub-groups, in order to bring simplicity to the analysis and to avoid multiple result sets.

18 MoEW has issued permits for wind and solar PV; Solar PV is divided between permits 180 MW given and a loan for 150 MW from the World Bank.

19 Different methodological approaches (e.g., face value, reserve, cost, no-cost) may be taken to costing financial derisking instruments. Here, a cost approach has been taken for the 'take or pay clause in PPA' and 'government guarantee for PPA', and 'full indexing' totaling USD 91.3m; A reserve approach has been taken for 'public loans', 'political risk insurance' and "hedging mechanism and indexing to the dollar", totaling USD 56.1m. See Section 4.2.4 for sensitivity analyses on costing. See Annex A for details.

estimated as being USD 4.1 million, and the financial derisking instruments USD 67 million[20]. For hydro power, the costs until 2030 for policy derisking instruments are estimated as being USD 3.9 million, and for financial derisking instruments USD 23.9 million. For distributed solar PV with storage, the costs until 2030 for policy derisking instruments are estimated as being USD 4.2 million, and for financial derisking instruments USD 82.4 million and for distributed solar PV without storage, the costs until 2030 for policy derisking instruments are estimated as being USD 4.2 million, and for financial derisking instruments USD 39 million.

Table 1: The selection of public instruments to achieve the envisioned investment targets for wind energy, solar PV (utility and distributed) and hydro power.

Risk Category	Policy Derisking Instruments	Financial Derisking Instruments
Power Market Risk	• Streamline RFP process and standardized contracts. • Establishment of an enabling regulatory framework. • Transition to bilateral contract model with an Independent regulatory authority. • Exit plan for private generators.	N/A
Permits Risk	• Streamlined process for RE permits through ERA. • Contract enforcement and recourse mechanisms.	N/A
Social Acceptance Risk	• Awareness-raising campaigns. • Stakeholder outreach, including operators of private generators. • Fair compensation and resettlement plans. • Security concepts for project sites.	N/A
Developer Risk	• Capacity building for resource assessment (wind only). • Via ERA: feasibility studies; networking; training and qualifications; technology and O&M assistance; grid connectivity guarantees; incentives for highly skilled individual; Capacity building for labours Research and development; technology standards; exchange of market information.	N/A

20 Different methodological approaches (e.g., face value, reserve, cost, no-cost) may be taken to costing financial derisking instruments. Here, a cost approach has been taken for break-down of cost to the public for financial derisking instruments: USD 31.5m direct cost for the 'take or pay clause in PPA' and 'government guarantee for PPA', totaling USD 25m; A reserve approach has been taken for USD 41m as loss reserve for 'public loans', 'political risk insurance' and "hedging mechanism and indexing to the dollar" See Section 4.2.4 for sensitivity analyses on costing. See Annex A for details.

Grid/ Transmission Risk	• Strengthen EDL's management/ operational performance; enhance bill collection efficiency and phase out energy subsidies.	• Take-or-pay clause in PPA[21]. • Financial products by development banks to assist EDL in gaining access to capital/funding, secure grants for reconstruction.
Counterparty Risk	• Strengthen EDL's management and operational performance. • Policy support for national grid infrastructure development including fast term release, Immediate Repairs and Infrastructure Rehabilitation; build connection substations in war targeted areas.	• Government guarantee for PPA payments. • Concessional public loans to IPPs • Secure grants to cover infrastructure damage cost.
Financial Sector Risk	• Fostering financial sector reform towards long-term green infrastructure investment. • Strengthening financial sector's familiarity with renewable energy and project finance.	• Financial products by development banks or the Central Bank, to assist project developers to gain access to capital/funding.
Political Risk	• Security guarantees for investors. • Strengthen long-term policy commitment to Renewable Energy Projects. • Plan for alternative funding sources.	• Risk sharing products by development banks to address political risk, Political risk insurance for foreign investors.
Currency/ Macroeconomic Risk	N/A	• Risk sharing mechanisms to address currency risk (excluding private sector instruments such as hedging, interest rate swaps). • Government-backed credit lines and financial guarantees. • Establish hedging mechanisms backed by international financial institutions and fully indexing contracts (PPA or tariff-based for distributed) to USD.
Climate Risk	• Implement low climate impact technologies and streamline climate impact assessment for projects.	• Financial incentives for climate-resilient projects.

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

21 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.

Levelized 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, expressed as the Levelized Cost of Electricity (LCOE), are shown in Figures 3 below.

In the business-as-usual (BAU) scenario, wind energy, solar PV and hydro power are still less expensive than the baseline. The baseline technology mix considers primarily EDL's assets which include combined cycle gas turbine (CCGT) plants[22], open cycle gas turbine (OCGT), steam turbines and reciprocating engines working on heavy fuels oil, hydro power IPPs, private generators and installed distributed solar PV[23]. The modeling is based on a realistic scenario for renewable energy capacity installation following the permits that have already been approved by the MoEW[24]. This approach results in baseline generation costs of USD 23.9 cents per kWh, assuming unsubsidized tariffs and fuel cost as projected by leading international energy organizations and executive order from the ministry 2023 (see Appendix A). In comparison, wind energy in the BAU scenario is estimated at USD 15.1 cents per kWh, solar PV at USD 10.3 cents per kWh, and hydro power at USD 6.2 cents per kWh. This means that all three utility technologies wind energy, solar PV and hydro have no premium requirement (USD -8.8 cents per kWh, USD -13.6 cents per kWh and USD -17.7 cents per kWh, respectively) over the baseline energy technology mix–on the contrary, even before implementing de-risking measures, renewable energy are more cost effective than the current baseline energy mix in Lebanon. This also holds for distributed solar PV with storage and without storage having a BAU scenario cost of USD 24.7 with storage and USD 22.4 without storage, and a baseline generation cost for diesel mini-grids of USD 37.3, that leads to no premium requirement (USD -12.6 cents per kWh, USD -14.9 cents per kWh, respectively). This demonstrates that renewable energy technologies, wind, solar PV, and hydro are not only viable in utility and distributed configuration but also more economical than conventional generation sources including diesel-generator baseline, even under business-as-usual assumptions.

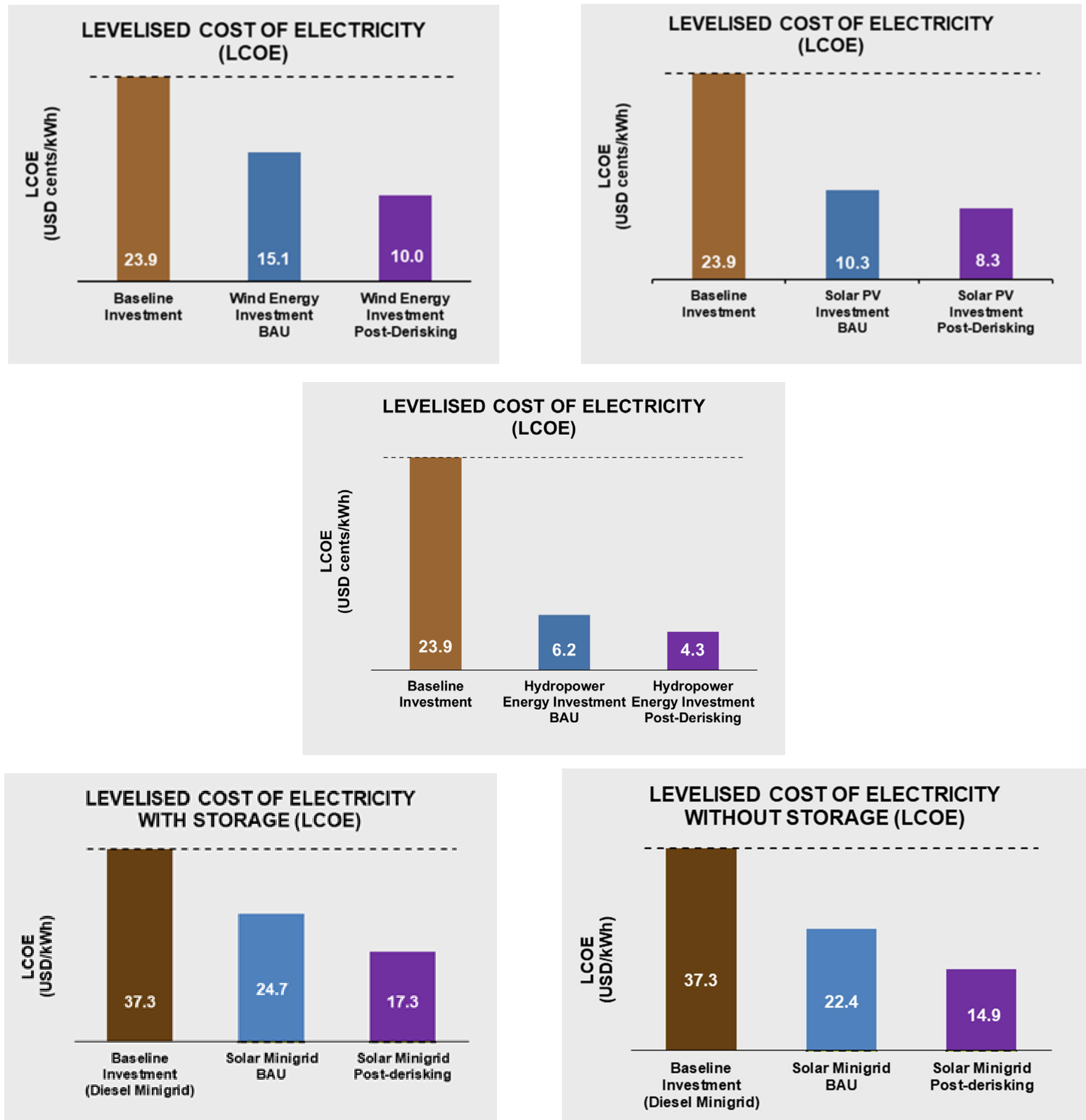
In the post-derisking scenario, the cost of wind energy falls to USD 10 cents per kWh, the cost of utility solar PV falls to USD 8.3 cents per kWh and hydro power falls to USD 4.3 cents per kWh. For distributed solar PV with storage the cost falls to USD 17.3 cents per kWh and the cost without storage falls to USD 14.9 cents per kWh assuming that it is a standalone system with no additional coverage from batteries. As such, following government interventions to derisk the investment environment, and with resulting in lower financing costs, the price for wind energy and solar PV is reduced by around 28% combined.

Figure 3: LCOEs for the baseline, wind energy (left up), solar PV (right up), hydro power (middle) distributed solar PV with storage (Left below) and distributed solar PV without storage (Right below) investment in Lebanon.

22 Currently operating on light fuel oil. The Reciprocating engines at Zouk & Jiyeh & the Thermal Power Plants operate on HFO.

23 In other words, renewable energy is compared to a generation mix of the already existing fleet plus private generators and private solar PV, reflecting 2025 energy market status.

24 As of 2025, a total of 226 MW in wind energy permits have been approved for the Hawa Akkar project. For solar PV, 180 MW across 12 permits have been granted and additional 150 MW from the world bank. For hydropower, 58 MW are part of the 2021 Least Cost of Energy Plan.



Source: modelling; see Table 30 (wind), Table 31 (solar PV), Table 32 (hydro) and table 33-34 (Distributed solar PV), as well as Annex A for details of assumptions and methodology.

Evaluation of public instruments' effectiveness

The DREI methodology uses four performance metrics to analyze the impacts of the selected public instrument package to promote investment, each metric taking a different perspective: the ability to catalyze 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).

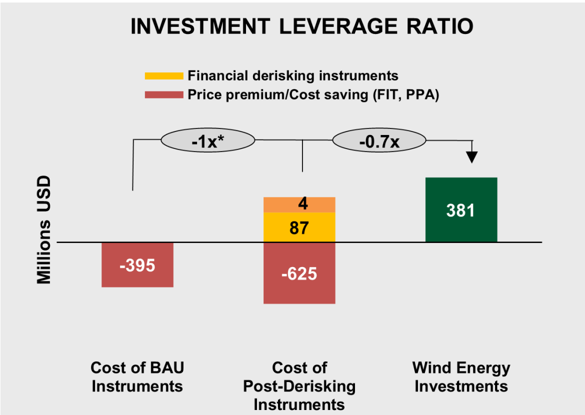
Figure 4 shows the results for two out of the four performance metrics, namely the leverage ratio and carbon abatement for wind energy:

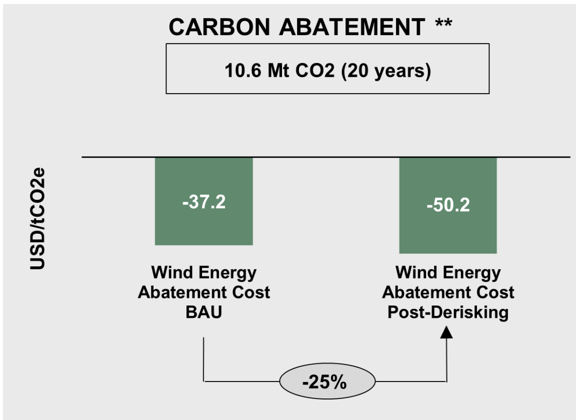
- For the leverage ratio, achieving the envisioned 2030 target of 226 MW in installed wind capacity equates to USD 381 million in private sector investment. In the business-as-usual scenario, the model estimates that achieving this target has a direct financial incentive in the form of cost savings over 20 years of USD 395 million. In the post-derisking scenario, the model estimates that this same investment target can be achieved with a package of derisking instruments valued at USD 91.6 million, with total cost saving of USD 624.9 million an additional USD 230 million in saving compared to BAU. It is important to note that, the additional savings generated not only enhance short-term cost efficiency but also enhance the conditions for long-term investor confidence and sustained renewable energy investment.

- For carbon abatement, achieving the 2030 target of 226 MW in wind energy is estimated to result in a total reduction of 10.6 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 USD -37.2 per tonne of CO_2e. Or, in other words, even without public instruments in place there is cost saving of USD -37.2 for every tonne of CO_2e abated in wind energy. In the post-derisking scenario, this cost saving falls even more to USD -50.2 per tonne of CO_2. 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 4: Performance metrics for the selected package of derisking instruments in promoting 226 MW of wind energy investment in Lebanon.





Source: modelling; see Table 30 and Annex A for details of assumptions and methodology.

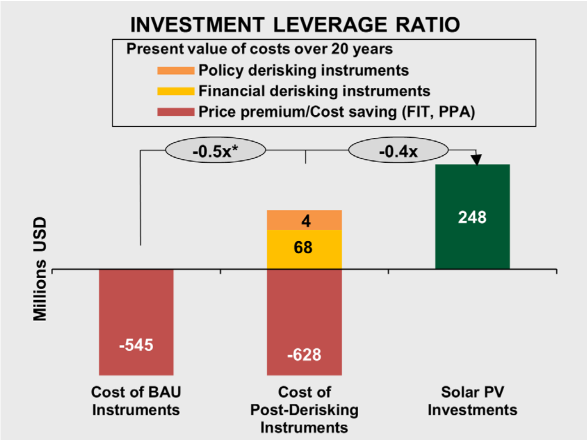
**In the BAU scenario, the full 2030 investment target may not be met.*

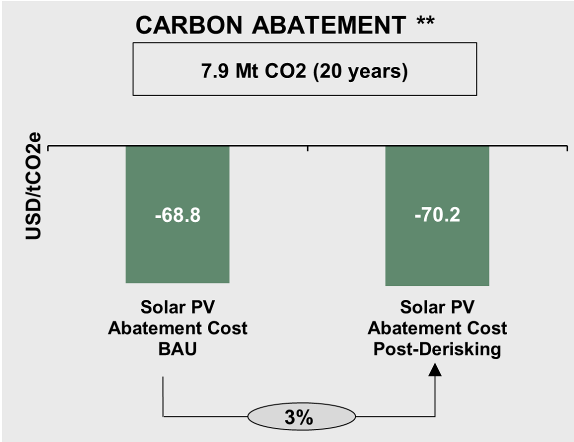
*** The Carbon Abatement metric can be broken down into the costs of policy derisking instruments, financial derisking instruments and the cost savings. While in the BAU scenario, the total of USD -37.2 per tCO_2 is due to the cost saving, in the post-derisking scenario, this breakdown for the total of USD -50.2 per tCO_2 is USD 0.41, USD 8.22 and USD -58.86, respectively.*

Figure 5 shows selected results for solar PV in Lebanon, this time with the envisioned 2030 target of 330 MW of large-scale solar PV private sector investment. The results demonstrate the beneficial impact of derisking even more strikingly than the case with wind energy.

Figure 5: Performance metrics for the selected package of derisking instruments in promoting 330 MW of solar PV investment in

Lebanon.



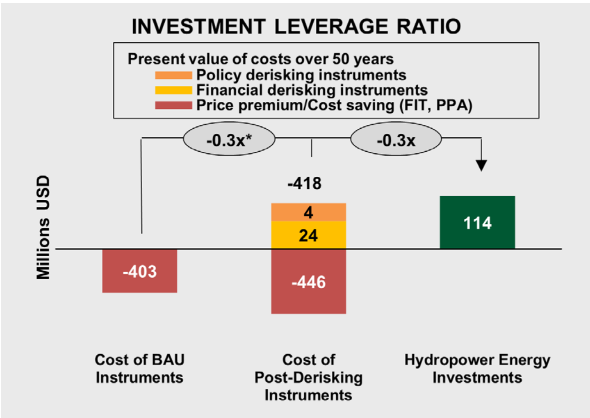


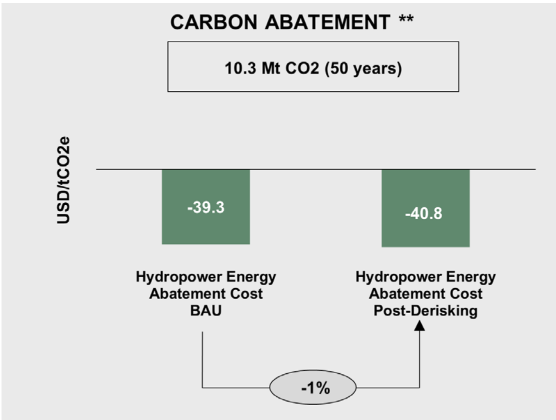
Source: modelling; see Table 31 and Annex A for details of assumptions and methodology.

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

*** The Carbon Abatement metric can be broken down into the costs of policy derisking instruments, financial derisking instruments and the cost savings. While in the BAU scenario, the total of USD -68.8 per tCO_2 is due to the cost savings, in the post-derisking scenario, this breakdown for the total of USD -70.2 per tCO_2 is USD 0.53, USD 8.54 and USD -79.25, respectively.*

Figure 6: Performance metrics for the selected package of derisking instruments in promoting 58 MW of hydro power from 2021 Least Cost Plan investment.





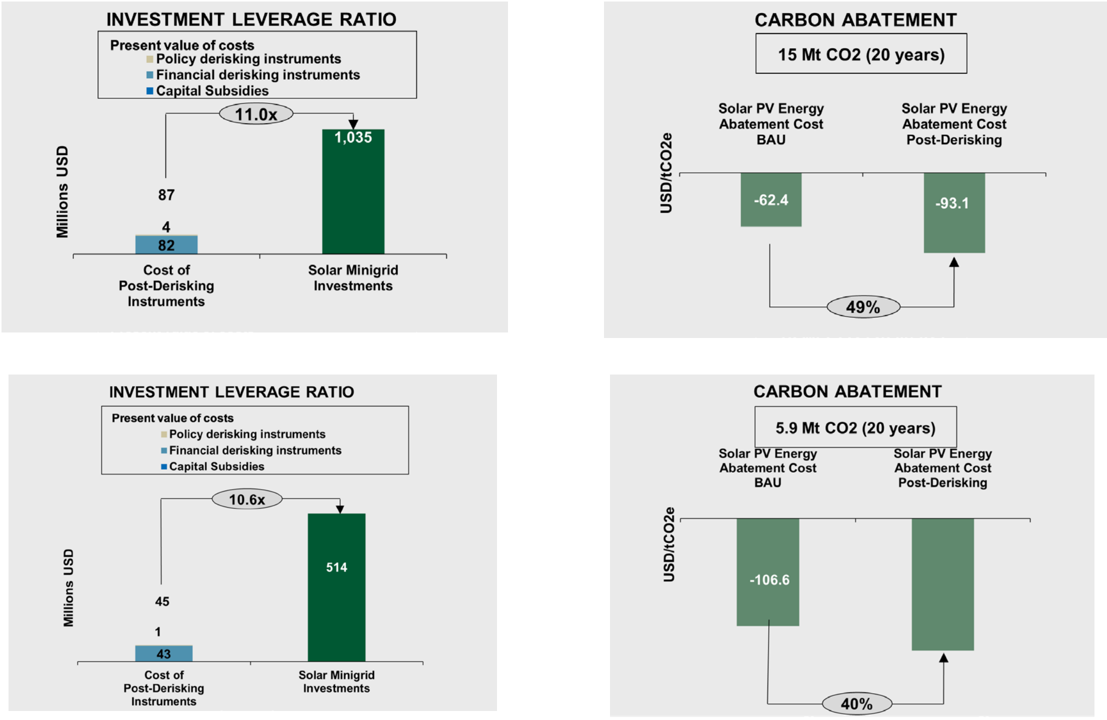
Source: modelling; see Table 32 and Annex A for details of assumptions and methodology.

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

*** The Carbon Abatement metric can be broken down into the costs of policy derisking instruments, financial derisking instruments and the price premium. While in the BAU scenario, the total of USD -39.3 per tCO_2 is due to the price premium, in the post-derisking scenario, this breakdown for the total of USD -40.8 per tCO_2 is USD 0.39, USD 2.3 and USD -43.5, respectively.*

Figure 7: Performance metrics for the selected package of derisking instruments in promoting 1,200 MW of distributed solar PV

investment in Lebanon with storage (above) without storage (below).



Source: modelling; see Table 33 Table 34 and Annex A for details of assumptions and methodology.

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

*** The Carbon Abatement metric can be broken down into the costs of policy derisking instruments, financial derisking instruments and the price premium. While in the BAU scenario with storage, the total of USD -62.4 per tCO_2 is due to the cost savings, in the post-derisking scenario, this breakdown for the total of USD -93.1 per tCO_2 is USD 0.28, USD 5.49 and USD -98.85, respectively. For the BAU scenario without storage, the total of USD -46.0 per tCO_2 is due to the cost savings, in the post-derisking scenario, this breakdown for the total of USD -63.7 per tCO_2 is USD 0.29, USD 5.82 and USD -69.82, respectively.*

All the models for the three technologies show a cost saving in BAU and post-derisking as opposed to the baseline energy mix. This means even before taking the derisking measures, renewable energy is much more cost effective than Lebanon baseline energy mix.

Sensitivities

Sensitivity analyses can assist in gaining a better understanding of the robustness of the outputs and to be able to test different scenarios. Three broad types of sensitivity analysis have been performed on (i) key input assumptions, such as investment cost, capacity factors and fuel costs, (ii) on public instrument selection and cost-effectiveness and (iii) on the approach to costing financial derisking instruments. The sensitivities on public instrument selection show a range of cost-effectiveness, but that overall implementing public derisking instruments is always more cost effective than paying higher generation costs, across all scenarios[25].

Detailed results for the sensitivities can be found in section 4.2.4.

Conclusions

25 Unlike the 2013 DREI model for utility-scale renewable energy, the DREI mini-grid model does not include sensitivity analysis for public instruments. This limitation is due to the model's design and not the scope of the analysis, as the functionality for sensitivity testing is only available for utility-scale systems.

Implications for promoting renewable energy in Lebanon

The results confirm that financing costs for wind energy, solar PV and hydro power in Lebanon are currently very high, particularly in comparison to countries with more favorable investment environments. The cost of equity for wind energy, solar PV and hydro power in Lebanon today is estimated at 26%, and the cost of debt at 13%[26]. The modelling evaluates ten different risk categories regarding their contribution to these higher financing costs in Lebanon. Five of these–permit risk, grid/transmission risk, counterparty risk, political risk, currency risk–are large contributors to high financing costs, increasing the cost of equity by more than 1.5% point (100 basis points) each[27].

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 envisioned investment objectives as per the permits already given in Lebanon as of 2025. The derisking measures that are modelled bring down the generation cost of wind energy from USD 15.1 cents per kWh to USD 10.0 cents per kWh, solar PV energy from USD 10.3 cents per kWh to USD 8.3 cents per kWh[28], hydro power from USD 6.2 cents per kWh to USD 4.3 cents per kWh, distributed solar PV with storage from USD 24.7 cents per kWh to USD 17.3 cents per kWh and distributed solar PV without storage from USD 22.4 cents per kWh to USD 14.9 cents per kW[29].

The modeling also shows that investing in derisking measures offers strong value for money, especially when compared to the cost savings already achieved under BAU scenarios for wind energy, solar PV, and hydropower.

- For wind energy, in the business-as-usual scenario, the modelling estimates could lead to cost savings totaling USD 394 million that can be achieved over the next 20 years. However, if a total of USD 92 million is invested in derisking measures (USD 18 million per year until 2030[30]), achieving the target permits[31], wind energy costs will decrease by 33.8%, resulting in additional savings of USD 230 million, thereby this approach would lead to total generation cost savings of USD 625 million over the next 20 years.
- For solar PV, in the business-as-usual scenario, the modelling estimates could lead to cost saving of USD 545 million over the investment's lifespan of 20 years. However, if a total investment of USD 71 million in derisking measures (USD 14.2 million per year until 2030) is made, achieving the target permits[31], solar PV cost will also become 20% cheaper and the cost saving are reduced even more to USD 628 million, saving USD 83 million in generation costs over the next 20 years.

26 USD-denominated cost of equity and cost of debt.

27 Financial sector risk has also a high impact on financing cost, and it could be interchangeable with other risks.

28 LCOE for utility-scale solar PV is higher than theoretical estimates and the values suggested by existing permits. This exercise incorporates the Capital Asset Pricing Model (CAPM) to account for the cost of equity, as well as the elevated risk associated with Lebanon's post-2019 economic crisis and the 2024 conflict.

29 The solar PV generation cost for the mini-grid system without storage is lower than the solar PV generation with storage due to the absence of investment in lithium batteries.

30 Annual costs are given in 2024 USD.

31 For wind energy 226 MW, for solar PV 330 MW, for hydro power 58 MW and 1,200 MW for distributed solar PV.

- For hydro power, in the business-as-usual scenario, the modelling estimates could lead to cost saving of USD 403 million over the investment's lifespan of 50 years. However, if a total of USD 28 million is invested in derisking measures (USD 5.6 million per year until 2030), achieving the target permits[31], hydro power cost will decrease further, resulting in additional savings of USD 43 million, saving USD 446 million in generation costs over the next 50 years.
- For distributed solar PV with storage, in the business-as-usual scenario, the modelling estimates that there is an economy-wide savings when investing in solar mini-grid totaling USD 937 million over the lifespan of the investment of 20 years. However, if a total investment of USD 86 million is made in derisking measures (USD 17 million per year until 2030) distributed solar PV power will also become 32% cheaper and the cost saving are reduced even more to USD 1.5 billion, saving USD 543 million in generation costs over the next 20 years due to derisking.
- For distributed solar PV without storage, in the business-as-usual scenario, the modelling estimates that there is a cost saving when investing in solar mini-grid totaling USD 584 million over the lifespan of the investment of 20 years. However, if a total investment of USD 45 million is made in derisking measures (USD 9 million per year until 2030) achieving the target permits given, distributed solar PV power will also become 33% cheaper and the cost saving are reduced even more to USD 877 billion, saving USD 293 million in generation costs over the next 20 years.

Overall, the findings suggest that implementing derisking instruments immediately should be prioritized wherever possible. This approach will help mitigate residual risks and encourage investors to finance renewable energy projects in Lebanon.

Next steps

The results in this report should not be interpreted as a definitive quantitative analysis of wind energy, solar PV and hydro power in Lebanon 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.

1. INTRODUCTION

1. Introduction

As of July 2025, Lebanon has seen the establishment of a new government, which remains actively engaged in shaping the nation's energy landscape. This administration is currently in the process of developing updated renewable energy targets that will guide policy and investment decisions for the years ahead. Amidst these ongoing deliberations, the Ministry of Energy and Water has demonstrated unwavering consistency in its approach. It continues to affirm its steadfast commitment to progressing with the implementation of all previously issued permits for wind and solar projects, 226 MW and 330 MW, respectively. The 2021 Least Cost of Energy Plan proposes the construction of 58 MW of new hydropower plants. Lebanon also has approximately 1,400 MW of distributed solar PV already installed. For the purpose of this study, an additional scenario is being considered: the deployment of 1,200 MW of distributed solar PV under two configurations—one with energy storage and one without. This approach enables a comprehensive analysis of the potential benefits and impacts of distributed solar PV solutions both with and without integrated storage systems[32].

The Ministry's stated objective is to ensure that these permitted installations are successfully commissioned and brought online by 2030, provided feasibility assessments remain favorable throughout the process. In parallel, government agencies and stakeholders are closely reviewing the country's overall projected energy demand for 2030. However, it is important to note that, as of this writing, no final or definitive figures have been released regarding the anticipated national energy requirements for that horizon, reflecting the dynamic and evolving nature of Lebanon's energy sector planning.

While these targets are broadly consistent with Lebanon's Nationally Determined Contributions (NDC)—which outline an unconditional target of 18% and a conditional target of 30% renewable energy by 2030. As of 2022, Lebanon's total primary energy demand had declined by 33% from its 2019 peak, but amid the country's gradual recovery and stabilization following the 2024 conflict, economic growth remains modest yet positive. Projections estimate that Lebanon's GDP will grow by approximately 4% annually through 2030, reflecting a cautious optimism as the nation regains its footing. Correspondingly, electricity demand is expected to increase, with forecasts suggesting it will reach around 21,865 GWh by 2030.

Key technologies for meeting Lebanon's 2030 vision continue to include onshore wind farms, utility and distributed solar photovoltaic (PV), and hydro run-of-river installations. According to the Ministry of Energy and Water (MoEW, 2022), previous targets set for 2026 included 746 MW of wind energy, 680 MW of utility-scale solar PV, and 394 MW of hydro power. The Distributed Solar PV initiative also aimed at 2,400 MW by 2030, adding 1,200 MW to the 1,200 MWp already installed[33]. However, due to recent setbacks, the 2026 milestones are no longer viewed as attainable, and timelines have shifted to 2030. Given recent governance changes and increased volatility in the energy sector, a more pragmatic approach has been adopted. After extensive consultations, it was agreed to focus on projects with committed permits from the Ministry: 262 MW of wind, 330 MW of utility-scale solar PV, an additional 58 MW of new hydro power,

32 Distributed solar scenarios will be considered separately and not combined to achieve a 2,400 MW target by 2030.

33 By 2024, 1,400 MW was installed, however due to the November 2024 war, around 16-18 MW of solar PV was destroyed across Lebanon.

and 1,200 MW of distributed solar PV by 2030. This revised scenario, is expected to advance Lebanon toward its unconditional 18% renewable energy target.

MoEW envisages utility-scale RE projects to be financed through private investments or public financing, given the timely set-up of an appropriate legal framework. However, like in most developing economies, Lebanon's market for larger RE infrastructure is in its very early days. Regulatory barriers are but one out of a suite of investment risks that force up financing cost and may thus prevent the private sector from engaging in large-scale RE investments.

Before the 2019 economic crisis, planned initiatives were seeking to promote small-scale renewable energy and energy efficiency investments in Lebanon, including in the green building domain. These are outside the scope of this analysis, with its focus on large-scale renewable energy, while considering in our analysis and baseline approach the already existing distributed solar PV installed.

This report, using the Derisking Renewable Energy Investment (DREI) methodology developed by UNDP, sets out the modelling results for systematically assessing investment risks and selecting public instruments to attract renewable energy investment also in large-scale projects. This is crucial to meet the targeted and envisioned renewable energy capacity by 2030. Ultimately, adding wind energy, solar PV and hydro run-of-river to the grid will increase security of supply with energy that is clean and affordable–to the benefit of Lebanon's people, economy, and environment.

2. OVERVIEW OF THE DERISKING RENEWABLE ENERGY INVESTMENT METHODOLOGY

2. Overview of the Derisking Renewable Energy Investment Methodology

In 2013, UNDP issued the Derisking Renewable Energy Investment report (the “DREI report”) (Waissbein et al., 2013) and in 2018, the Derisking Renewable Energy Investment: off-Grid Electrification (the “DREI report”) (Waissbein et al., 2018[34]). The reports introduced an innovative methodology (the “DREI methodology”), to quantitatively compare different public instruments for promoting renewable energy investment. This section provides an overview of the following aspects of the DREI methodology[35]:

- 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 full 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[36], 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 8 below, from the DREI (2013) 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 8%; cost of debt of 4%), and a high financing cost environment for the developing country (cost of equity of 18%; cost of debt of 10%), as an example. 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[37].

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 9.3 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

34 Available for download at www.undp.org/DREI.

35 Both Reports for distributed and utility scale R.E have a similar methodology. As a matter of fact, Off-grid electrification (distributed) uses the DREI 2013 methodology and instruments cornerstones. In this study, instruments for utility-scale and distributed technologies were grouped due to their strong similarities.

36 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).

37 The original study was conducted in 2013, at a time when the initial investment costs for renewable energy were significantly higher than those for thermal power plants. This example is for the purpose of explaining what and how is the DREI study conducted.

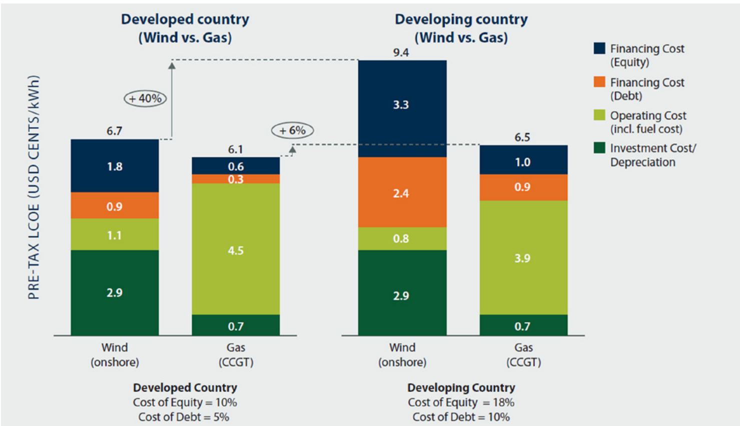
percent more expensive due to these same higher financing costs. As such, in the developing country, wind power is no longer competitive with gas in this high financing cost environment.

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. Unlike fossil fuel projects, renewable energy investments typically require substantial upfront capital for equipment and installation—think of the high initial costs associated with wind turbines, including their towers, blades, and gearboxes—all vital components needed to generate electricity efficiently. However, solar panels technology is becoming increasingly mature and economically cheaper. This study will showcase rather a different case for solar PV with an LCOE much lower than thermal plants due to a lower initial cost compared to 2014 and low operating cost compared to growing price of fuel[38]. Following the initial investment, renewable energy technologies typically incur very low operating and maintenance costs and require no fuel. Fossil fuel-based generation, by contrast, is characterized by lower upfront costs but high and volatile operating and fuel expenses. However, this cost structure is rapidly evolving. According to the International Energy Agency (IEA, 2024), the capital costs of solar PV and wind have continued to decline, making them not only competitive but often cheaper than new thermal power plants in many regions. In fact, solar PV is now among the most cost-effective sources of new electricity generation globally, with each dollar invested yielding significantly more energy than a decade ago.

Consequently, while high financing cost environments still disproportionately penalize capital-intensive renewable energy projects, the narrowing—and in some cases reversal—of the CAPEX gap between renewables and fossil fuels strengthens the economic case for clean energy investments.

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.

Figure 8: 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 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.

38 This also hold true for wind and hydro power, as technologies has advanced significantly since the DREI study was published in 2013.

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.

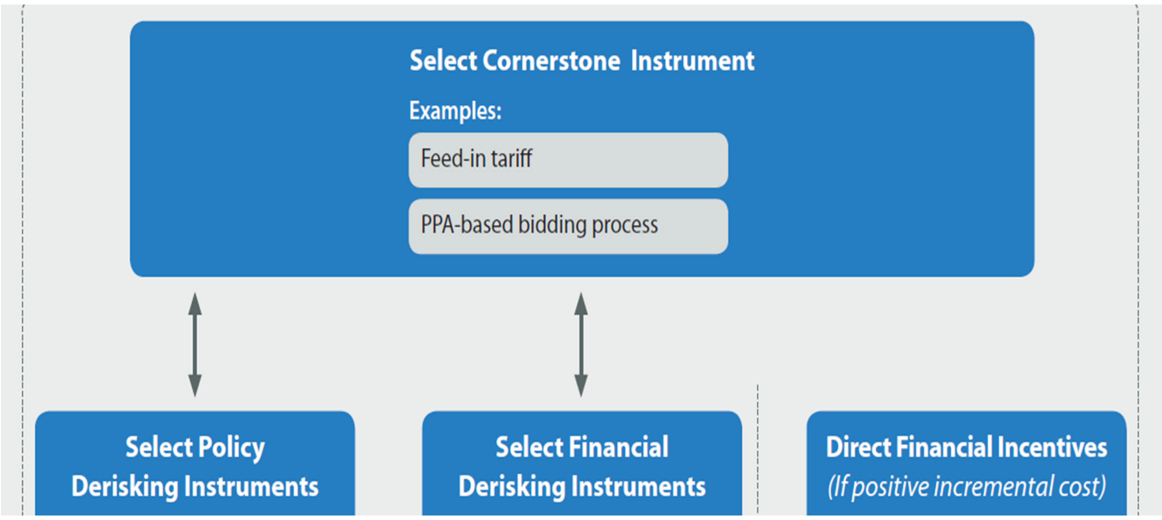
From a financial perspective, the overall aim for policy-makers in assembling a public instrument package is to achieve a risk-return profile for renewable energy that can cost-effectively attract private sector capital. Figure 9 below, from the DREI report 2013, identifies the four key components of a public instrument package that can address this risk-return profile.

The cornerstone instrument is the central element of any public support package. While many public instruments exist, only a few have proven highly effective in driving real market transformation. For large-scale renewable energy, the cornerstone instrument is typically a Feed-in Tariff (FiT) or a Power Purchase Agreement (PPA) tender, both of which allow independent power producers (IPPs) to enter into long-term (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 utilize 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".**

Figure 9: 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 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 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 10, the methodology[39] is organized 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: Levelized 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 and transparent process whereby key inputs and assumptions are made explicit, so that they can contribute to and inform the design process.

39 Same methodology used for the off-grid electrification analysis.

Figure 10: 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 sensitivities on key inputs and assumptions

Source: Derisking Renewable Energy Investment (UNDP, 2013).

3. CURRENT STATUS OF WIND ENERGY, SOLAR PV AND HYDRO POWER IN LEBANON

3. Current Status Of Wind Energy, Solar PV And Hydro Power In Lebanon

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

Lebanon General Country Data[40]
Population 2024: 5.8m
Land Area: 10,452 sq. km
GDP 2024 (USD): $28.25 billion
GDP/capita (USD, PPP) 2024: $5,280
Sovereign rating 2024: In default, C (Moody's), SD for foreign currency debt and CC for local currency debt (S&P)
UNDP HDI 2014: 0.723 (109th of 191)

2030 Targets for wind energy and solar PV

There is strong potential for renewable energy in Lebanon. The country is well positioned for investment, supported by dynamic domestic business and financial sectors. Renewable energy can play a transformative role in Lebanon's power sector by addressing unmet electricity demand, enhancing supply reliability, reducing dependence on fuel imports, improving the affordability of the energy mix, and lowering the need for subsidies to Électricité du Liban (EDL).

While there is currently an unconditional binding target of 18% and a conditional target of 30%[41] for renewable energy in the generation mix by 2030[42], the Government of Lebanon has formally adopted these targets as part of its national energy strategy. Lebanon's 2025 NDC targets are aimed for the year 2035, with 25% RE generation (unconditionally) and 30% with international support. Thus, we estimate that Lebanon's GDP will grow by approximately 4% annually through 2030, reflecting a cautious optimism as the nation regains its footing. Given the high cost of thermal energy in Lebanon following the removal of subsidies and the tariff adjustments in 2022, the MoEW plan translates RE targets into specific capacity goals: 746 MW of wind energy, 680 MW of utility-scale solar PV, and 394 MW of hydropower, along with a target of 2,000 MWp of distributed solar PV. By the end of 2023, Lebanon had already installed 1,254 MWp of distributed solar PV, with a modest increase to 1,400 MWp in 2024. The 2024 War on Lebanon had some damage to already installed solar PV which amounted as per the RDNA to 16-18[43] MW, around 1.3% of total installed solar PV.

40 Sources: International Monetary Fund–World economic outlook database,2024 ; Moody's, Standard & Poor's; UNDP.

41 Lebanon's Nationally Determined Contributions 2020.

42 This target is expected to be reached by installing 226 MW of wind energy, 330 MW of centralized solar PV, 2,000 MW of distributed solar PV and 58 MW of Hydro power, if the demand is adjusted to the current situation.

43 MoE/UNDP/GEF (2025). Assessment of Photovoltaic Panel Deployment in Lebanon (2020-2023) and 2024 war damage evaluation. Beirut, Lebanon.

However, the modeling presented in this report is based on a more conservative and realistic scenario, using investment targets derived from MoEW's already issued permits. These include 262 MW of wind energy, 330 MW of utility-scale solar PV, and an additional 58 MW of hydropower. In line with MoEW's policy direction, these investments are assumed to be fully financed by the private sector.

It is possible to envision even more ambitious investment targets for renewable energy. There is likely sufficient power demand to absorb such more ambitious renewable energy targets.

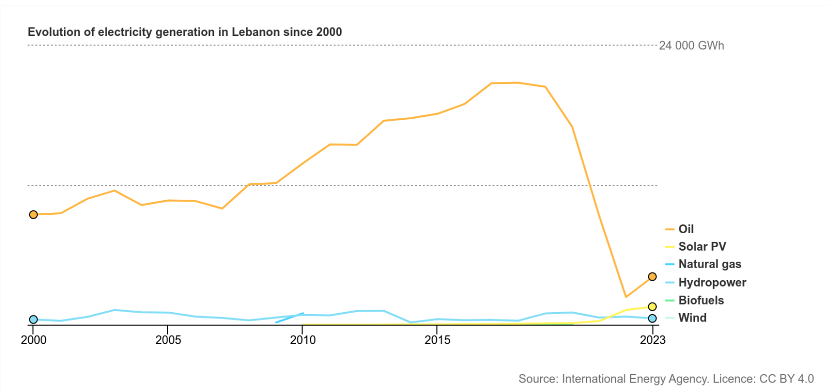
Power sector context

Lebanon's power sector is characterised by a significant supply-demand imbalance, high generation costs and a lack of financial sustainability. This situation has persisted for the better part of the past 30 years since the end of the Lebanese civil war in the early 1990s.

Électricté du Liban (EDL), the national utility, has an installed capacity of 2,360 MW[44], excluding Hydro power IPPs, but due to the relatively poor condition of its generation infrastructure, only approximately 1,775 MW[45] capacity are available (Table 2). This is far below peak demand, which can reach up to 3,844 MWp[46] during the summer months, before the financial crisis. In addition to the sub-standard generation infrastructure, the use of costly fuel oil, heavy fuel oil and diesel, coupled with tariff levels and collection rates that cannot cover these costs, further dampen the ability of EDL to purchase fuel and deliver electricity to customers. Between 2010 and 2020, annual budgetary transfers to EDL averaged 3.8 percent of GDP[47]. Furthermore, technical and non-technical losses on the network are very high. EDL released a report estimating technical transmission and distribution losses at 18.9% and noting that around 26.9% of total power generated was not billed in 2023[48].

Moreover, as set out in Figure 11, the evolution of electricity generation in Lebanon since 2000 and up to 2020, the dominance of oil is evident, however from 2022 and due to the financial crisis, oil consumption for national power supply has collapsed. Compensating action by Lebanese citizens and institutions are mostly directed at local diesel generators and investing in private solar PV systems.

Figure 11: Electricity generation by fuel in Lebanon (2000 to 2022).



Source: (https://www.iea.org/countries/lebanon/energy-mix)

44 Source: Statistics from EDL, directly communicated to authors. Including Beirut snake solar project.

45 World Bank Group, 2020. Lebanon Power Sector Emergency Action Plan. World Bank Group.

46 RE-ENERGIZE LEBANON. American University of Beirut.

47 RE-ENERGIZE LEBANON. American University of Beirut.

48 3RF meeting dated March 2024.

Due in large part to the predominance of fuel oil, a relatively expensive source of power, and exacerbated by aging infrastructure, Lebanon is burdened with high generation costs. Electricity prices to the end-users were not cost-reflective. Since the last tariff adjustment in 1996, prices were stagnant, but by 2023, tariffs were raised significantly, helping to reduce the financial strain on Électricité du Liban (EDL). The tariffs have been adjusted to better reflect the actual costs of production–subsidized block, x ≤ 100 kWh for 10 ¢/kWh and Non-subsidized block, x>100 kWh for 27 ¢/kWh. Despite this, the sector remains costly as EDL's production cost is higher than regional averages. In 2023, EDL covered about 26% of the country's electricity demand only.

Moreover, the capacity of the existing power generation plants, as shown in Table 2[49], is not enough to cover the national demand. Generation assets include hydroelectric plants and thermal power plants, such as the Zahrani and Deir Ammar plants, which primarily run on fuel oil although they were designed for natural gas. The insufficient combined generation capacity of these plants, and the inability to operate them nearer to their nominal capacity lead to frequent power outages and an increased reliance on private generators to fill the gap.

Table 2: Electricity generation power plants in Lebanon.

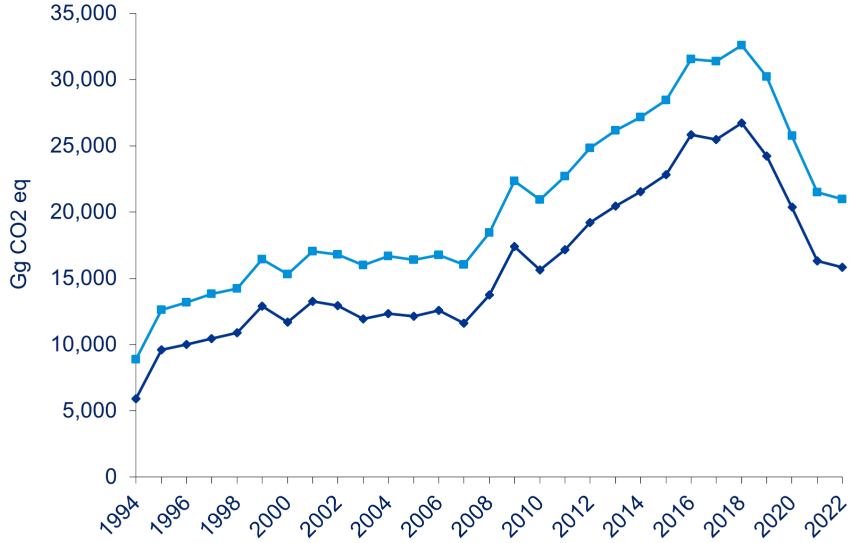
Plant Name	Fuel Type	Technology	Design Capacity (MW)	Derated Capacity (MW)
Zouk	Fuel Oil (Grade A)	Steam Turbine	607	300
Jieh	Fuel Oil (Grade A)	Steam Turbine	343	140
Zouk Recip	Fuel Oil (Grade B)	Recip	194	194
Jieh Recip	Fuel Oil (Grade B)	Recip	78	78
Zahrani	Gas Oil	CCGT	469	435
Deir Amar	Gas Oil	CCGT	464	435
Baalbak	Gas Oil	OCGT	64	60
Sour (Tyr)	Gas Oil	OCGT	72	60
Safa (Richmaya)	Hydro	Hydro	13	12
Beirut River Solar Snake (BRSS)	Green energy	Solar PV	1	1
Naameh	Biogas	Biogas	7	7
Litani Hydro	Hydro	Hydro	199	90
Nahr Ibrahim	Hydro	Hydro	32	17
Bared	Hydro	Hydro	17	6
Kadisha	Hydro	Hydro	21	15
Hrayche	Fuel Oil (Grade A)	Steam Turbine	70	45
Zahle	Gas oil	Internal Combustion Engines	60	-

Note: this table is extracted from the world bank report "Lebanon cost of service and tariff design study". EDZ is not mentioned in the world bank report.

49 These number are from the World bank: Lebanon cost of service and tariff design study and crossed checked with EDL's numbers.

Lebanon's electricity sector has had an impact on the country's national debt, culminating in a default on sovereign debt payments. Électricité du Liban (EDL) has traditionally received annual subsidies ranging between $1 and $2 billion to cover the losses resulting from the high costs associated with electricity production and distribution, and the tariffs fixed by Lebanon's Government in 1996. These subsidies led to significant debt accumulation over more than 30 years, leading to financial and social repercussions on both the economy and households. A lack of good infrastructure and investments in the energy sector marked by frequent power outages, has forced companies and households to invest in alternative energy sources such as private generators and recently solar PV. This reliance on neighborhood diesel generators has exacerbated issues related to air pollution and income loss. The carbon emissions from the sector are likewise extensive and have been increasing over time, at least until 2019 as shown in Figure 12. Energy-related CO_2 emissions accounted for approximately 77% of total emissions between 1994 and 2022.

Figure 12: Lebanon Total & Energy-related GHG Emissions (UNDP 2024 data).



Source: UNDP (2024) data – modelled by KPMG.

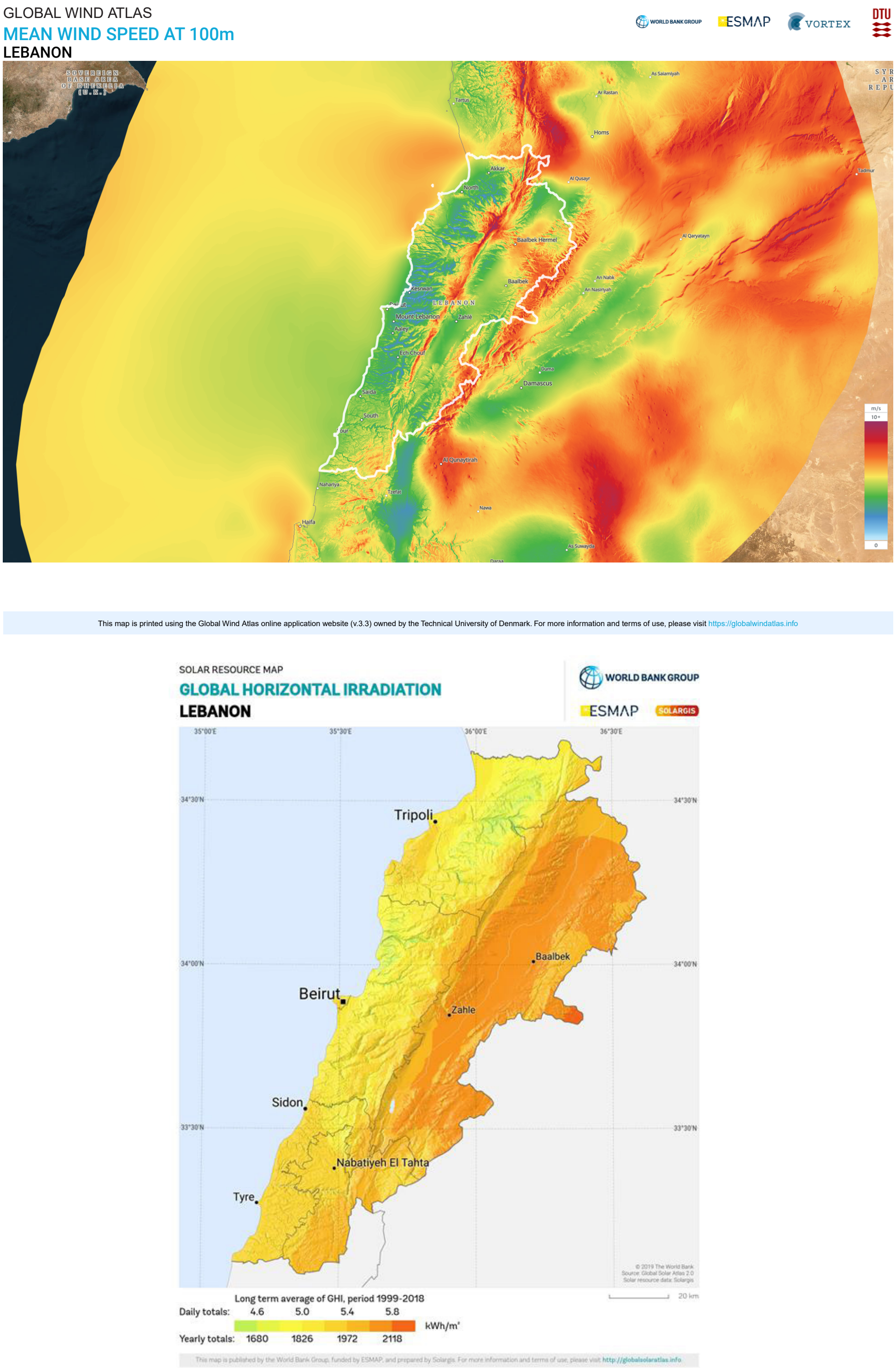
The above situation presents significant challenges that can be turned into opportunities. Renewable energy can play a vital role in transforming the power landscape in Lebanon towards a more sustainable reality.

Renewable energy resources

Lebanon has significant wind energy and solar potential. Figure 13 below shows wind and solar resource maps for Lebanon. Wind sites with strongest wind speeds are found along the eastern and northern borders to Syria (Beqaa and North Governorate) as well as along the mountain ranges, especially the Mount Lebanon range. The wind power analysis estimates a minimum energy generation potential of 1.5 GW, with an average annual energy generation potential of up to 6.1 GW.

Lebanon has 300 days of sun per year with solar irradiation levels exceeding 1,500 kWh/m^2 across the entire country and particularly high values in the eastern regions, such as the Beqaa Valley. According to IRENA, the country's solar irradiation varies between 1,520 kWh/m^2/year and 2,148 kWh/m^2/year, with the majority of areas receiving more than 1,900 kWh/m^2/year. This makes Lebanon highly suitable for PV installations. IRENA's analysis estimates that Lebanon could potentially develop up to 182 GW of utility-scale solar PV capacity, utilizing over 5,558 km^2 of suitable land for solar development[50].

Figure 13: Resource maps for wind and solar in Lebanon.



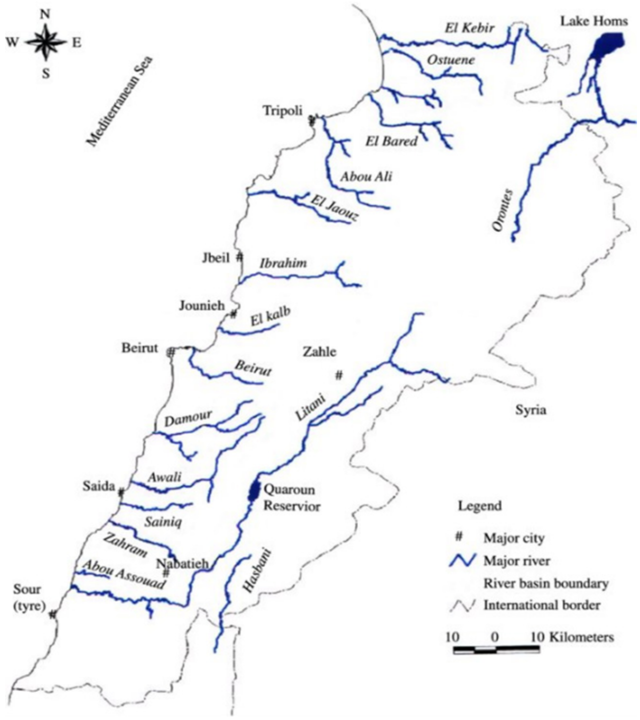
Source: CEDRO - The National Wind Atlas of Lebanon (CEDRO, 2011); Focus Solar 2009, Global Horizontal Irradiance, GHI, Annual value 2007 in kWh/m^2.

50 Renewable energy outlook Lebanon (2020).

The modelling uses a capacity factor of 25.6% for wind energy, and 19.8% for solar PV.

Moreover, Lebanon has an average annual rainfall of 800 mm, comparable to Germany, with a significant yet untapped hydropower potential[51]. The sector has been a vital part of the country's energy strategy, with key installations along rivers such as the Litani river. Current infrastructure spans both large and smaller scale facilities, including key plants like Qaraoun on the Litani River. Figure 14 illustrates the main rivers with hydro power in Lebanon along with their flow capacities, highlighting the country's renewable energy prospects. The Litani River enables Lebanon to generate approximately 405 GWh each year[52].

Figure 14: Lebanon water resources



Source: Lebanese Republic Hydropower Development in Lebanon report (2017).

Current status of Wind, Solar PV and Hydro Power Investments

Wind Energy

To date, there have not been any investments in wind farms in Lebanon, except for limited investments by a few private sector parties in preparatory studies and analyses required to reach financial close. The Ministry of Energy and Water (MoEW) started a procurement process for wind power in March 2013, with a tender for a 50-100 MW wind farm[53]. Three private sector consortiums applied to the tender with a cumulative capacity of 226 MW. A power purchase agreement (PPA) was signed between the MoEW and the three developers on February 1st, 2018. The final negotiated prices were approximately 9.6 ¢/kWh. However, as of 2025, this process, which has now extended over 11 years, has not led to the construction of Lebanon's first wind farms. Several factors have contributed to this delay, many of which are tied to the

50 Lebanon - Climatology | Climate Change Knowledge Portal.

51 Numbers are extrapolated from the Electricity production of EDL.

52 Source of the number is MoEW (2013), Request for Proposal: Wind Energy Power Project.

risks and barriers associated with developing renewable energy systems in Lebanon and will be further elaborated in this updated DREI report. A major reason for the delay has been Lebanon's deteriorated credit rating following its sovereign debt default and land ownership.

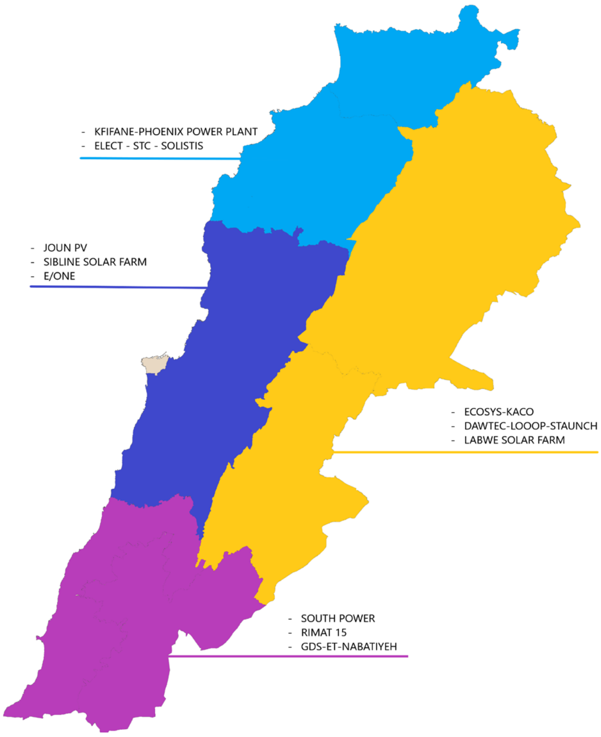
Solar PV

Solar PV systems in Lebanon are either utility-scale or distributed. For utility-scale solar, the MoEW likewise attempted to procure the first solar farms, launching an Expression of Interest (EOI) and Request for Proposal (RFP) in 2017 to acquire 180 MW of solar power through 12 solar plants, each with a maximum capacity of 15 MW, distributed across the country. The final negotiated price of the tariff was 5.7 ¢/kWh in the Beqaa region and 6.27 ¢/kWh for all other regions in Lebanon. The solar farms and their respective developers are shown in Figure 15 below. Moreover, in June 2025, a new loan agreement was signed with the World Bank "International Bank for Reconstruction and Development "to supply and install utility scale solar PV power plant of around 150 MWp, including the design, supply, and installation of the solar PV modules.

The country's first and only large-scale project is the Beirut River Solar Snake that was commissioned last year (1.1 MW, extension up to 10 MW is being considered). A second plant reaching 1.1 MW peak power as well is connected to the grid in southern Lebanon.

A Power Purchase Agreement (PPA) is being prepared for signature, however as with wind, the same barriers to investment and the default of the Lebanese Government have currently paused any real progress towards the first solar farms in the country.

Figure 15: Map of Solar farms per Governorate and chosen developers.



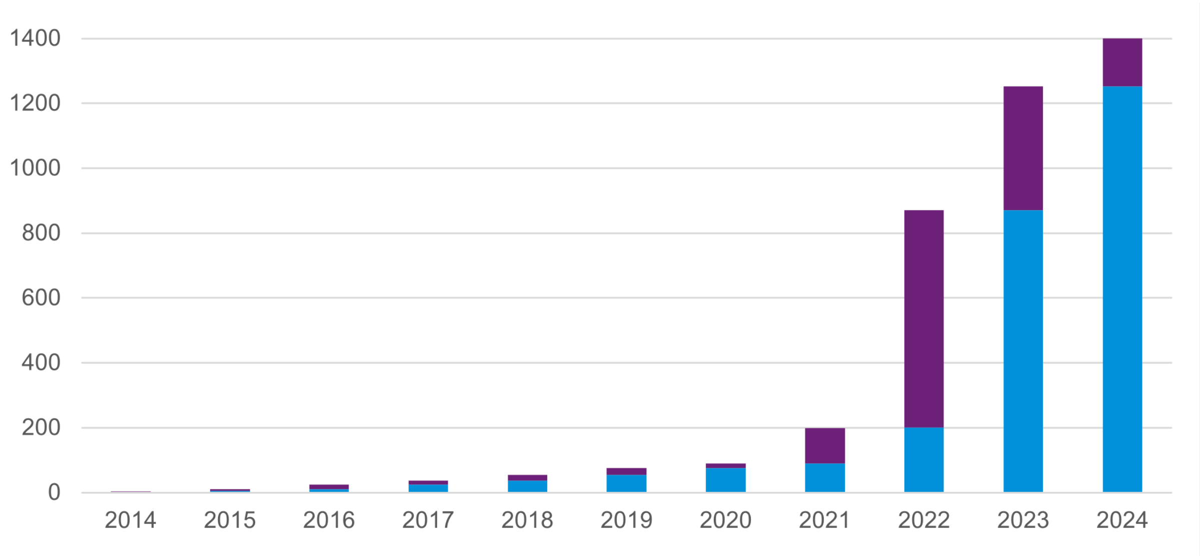
Source 2: LCEC solar PV farms – 180 MW bid.

The outlook for distributed solar PV in Lebanon has been notably different, largely due to the collapse of the power sector and the support from grants and subsidized loan programs by the donor community before the economic crisis in 2019.

By 2023, Lebanon had achieved a cumulative installed PV capacity of 1,253.98 MWp, generating approximately 1,793,824 MWh annually[54]. The districts of Baalbek, Zahle, Saida, Baabda, and El Metn had the highest concentrations of PV installations, with significant contributions from coastal and agricultural areas. PV installations were particularly prominent at elevations below 500 meters, covering a total area of 3.99 million m^2, with substantial installations in agricultural (540,587.5 m^2) and industrial zones (446,557.9 m^2). These systems provided essential energy for residential, commercial, and agricultural needs, mitigating the impact of Lebanon's ongoing electricity crisis. The increase in 2024 was minimal compared to the periods of 2020 to 2023 with a total installed capacity of 1,400 MWp.

The period from 2020 to 2023 saw significant growth in annual energy production additions, driven by the rapid deployment of photovoltaic (PV) systems. Installed capacity increased from 29.55 MWp in 2020 to 1,253.98 MWp by 2023, reflecting a substantial expansion in decentralized solar energy generation. This growth resulted in a corresponding rise in energy production, climbing from 84,448 MWh in 2021 to 1,793,824 MWh in 2023. The most notable increase occurred between 2021 and 2023, with a 1,240% rise in capacity additions, primarily fuelled by residential and commercial installations responding to Lebanon's ongoing energy crisis. By 2023, Baalbek emerged as the district with the highest cumulative solar PV capacity, followed by Zahle, Saida, and El Metn, highlighting regional disparities in solar energy deployment.

Figure 16: Distributed Solar PV capacity and annual additions.



Hydro Power

Lebanon has a long history of utilizing hydroelectric power, but the sector has seen minimal development or upgrades in recent years. Hydropower currently accounts for a small portion of Lebanon's total energy

54 The number are extrapolated from a World bank assessment of the damages: Lebanon Rapid Damage and Needs Assessment (RDNA).

generation capacity, with the country relying on aging infrastructure and limited capacity upgrades. A report by the World Bank in 2017 provides a comprehensive overview of the hydropower in Lebanon and identified key areas needed to improve the performance of this sector. Some of the barriers mentioned in the report, which are still valid in 2024, are[55]:

- Inadequate level payments towards existing hydro producers, compounded by the irregularity of the payments. This reality does not provide positive signals for any investments both in terms of rehabilitation of existing hydro stations or the construction of new ones.
- Existing gaps in the responsibilities and competencies of existing authorities and stakeholders in the hydropower sector, hindering the implementation of already ratified laws or governmental decisions, not allowing the development of the proper framework to support investment decisions.
- Unclear roles of stakeholders who are or should be the ones having the responsibility for the development of the hydropower sector through acting as a promoter of sector development, assessing the legal and regulatory framework, analysing the business environment, reporting regulatory developments and numbers, and standing in-between all other stakeholders facilitating their coordination and reconciling their interests and planning.

The World Bank (2017) provided some key recommendations to transform the sector, including yet not limited to;

- Development of an overall strategy for the hydroelectric sector aiming at upgrading the significance of hydroelectricity and undertaking initiatives on legal, administrative, policy and financial issues.
- Establishment of the Hydroelectricity Development Unit – a dedicated and specialized entity to enhance MoEW's capacity towards the development, management, and monitoring of hydropower projects.
- Establishment of the Hydro Account - a financial structure for the transactions related to potential agreements in order to minimize the exposure of the hydropower system development to the liabilities of the overall electricity market.
- Explicit allocation of the functions required for the efficient operation of the hydropower sector, including the execution of the agreements and the management of transactions between participating entities.

The hydro power PPAs price update is the following[56]:

Table 3: Hydro power PPA price per KWh

Hydro Plant	2023	2024	2025
Litani River Authority (LRA)	2.0 ¢/kWh	2.5 ¢/kWh	3.0 ¢/kWh
The Phoenician Society of Hydroelectric Forces of Nahr Ibrahim	2.0 ¢/kWh	2.5 ¢/kWh	3.0 ¢/kWh

55 World Bank, 2017. Hydropower Development in Lebanon: Assessment of the legal and administrative constraints to the development of the national hydropower market for Lebanon. World Bank Group.

56 This is following the 3RF meeting in March 2024.

Electrcity and distributed Renewable Energy laws in Lebanon

Law 462 to regulate the electricity sector has existed on paper since 2002, but has never entered into force. This law (to be viewed in conjunction with amended Law 288 and Law 54) is aimed at unbundling EDL, allowing private power generation and grid connection through independent power producers (IPPs).

Law No. 318 of 2023 establishes a legal framework for promoting distributed renewable energy production in Lebanon, comprising 12 articles that outline the principles and procedures for implementing distributed renewable energy projects. This legislation facilitates the integration of various renewable energy sources into the national grid and empowers private sector participation in the distributed renewable energy. It establishes mechanisms for different types of net metering, including individual, multiple-tenants, and collective net metering. Additionally, the law also facilitates peer-to-peer renewable energy trading among private sector entities through corporate power purchase agreements (PPAs) or the leasing of renewable energy equipment. Private organizations can generate and trade electricity from renewable sources, up to a maximum capacity of ten megawatts; however, trading is limited to adjacent plots, a restriction that has drawn concern from investors. The law covers both on-site and off-site power purchase agreements for the production and sale of renewable energy. Article 5 addresses the recycling of renewable energy and establishes guidelines for compensating surplus energy production. Article 6 designates the Electricity Regulatory Authority (ERA) with the responsibility of monitoring and surveillance of renewable energy production, including the development of a comprehensive database. Furthermore, EDL is tasked with overseeing participants, consumers, and producers in the renewable energy sector, with a dedicated Directorate for Renewable Energy to be established within EDL to implement the law and address related issues.

Although this law has been ratified, there are significant challenges to its implementation. The law itself highlights the need for the establishment of the Electricity Regulatory Authority (ERA), which has not been created since the enactment of Law 462 in 2002. Furthermore, the capacity and ability of Électricité du Liban (EDL), the national utility, to administer net metering in all its forms, manage off-site corporate PPAs, levy wheeling charges, and upgrade its metering infrastructure is currently severely lacking. Despite the recent legislative progress under Law No. 318 of 2023, investors in utility scale and distributed renewable energy systems face structural and regulatory uncertainties. Interviews with stakeholders revealed major concerns mainly, wheeling fees and restrictions on peer-to-peer energy trading by land plot limitations. Specifically, peer-to-peer trading is currently restricted to adjacent or shared plots, which limits the scalability and commercial viability of off-site corporate PPAs. Additionally, the absence of a clear framework for wheeling charges—the fees for using the public grid to transmit privately generated electricity—creates financial unpredictability for investors.

Interviews with investors in Lebanon have shown that there is considerable interest today from domestic private sector actors in implementing these laws. This interest continues despite the slow pace of power sector reform and procurement activities to date. Moreover, stakeholders stressed on the importance of establishing the ERA for regulating the energy market in Lebanon.

Post-war energy sector updates

Impact of the Conflict

The recent conflict inflicted extensive damage on Lebanon's energy infrastructure, resulting in significant financial and operational setbacks for the power sector. The total damages are estimated at US$ 97.92 million, while the losses amount to US$ 209.16 million. This substantial impact has severely disrupted the country's electricity supply and overall energy stability. A source from EDL mentioned that Dahyeh has seen significant damage, especially to low-medium voltage. The damage in the infrastructure includes substations and feeders. According to EDL, the damage was primarily on the infrastructure rather than the facilities, further complicating the restoration process. Table 4 below is the assessed damage cost from the 2024 conflict.

Table 4: Post-war 2024 infrastructure damage cost.

Asset Types	Total Cost ($m)
DAMAGE	
Transmission	**24.00**
MV equipment	4.33
HV equipment	4.73
Transformer	10.23
Mobile substation	4.73
Distribution	**73.92**
MV/LV Substations	18.15
MV Distribution Network	7.60
LV Distribution Network	30.17
Accessories	12.00
UGC Cables	5.99
Total Damage	**97.92**
LOSSES	
Financial losses of billable electricity generated and distributed by EDL	209.16
Total Loss	**209.16**

Source 2: New World Bank Report Assesses Impact of Conflict on Lebanon's Economy and Key Sectors.

The transmission network and substations were particularly hard-hit, with damage primarily concentrated in the El Nabatiyeh, Baalbek-Hermel, and South governorates. These areas experienced significant disruptions in electricity supply due to the extensive damage to transformers, Medium Voltage (MV) and High Voltage (HV) equipment. The highest concentration of damage was observed in El Nabatiyeh, which accounted for 50% of the total transmission network damage, followed by Baalbek-Hermel with 19%, and the South with 17%.

At the distribution level, the damage was even more widespread and severe. The MV substations, MV/LV distribution networks, and underground cables (UGC) in Beirut's southern suburbs were particularly affected. The total damage to the distribution network is estimated at US$ 74 million, with key infrastructure such as poles, cables, switchgears, transformers, and distribution panels being heavily impacted. The LV network sustained the most extensive damage, accounting for 38% of the total distribution damage, followed by MV substations at 26%.

The conflict also caused significant damage to decentralized power generation systems, including solar power systems deployed by households, businesses, and institutions, as well as diesel generators and associated networks. These systems were the primary source of electricity for many across the country, especially in the absence of reliable grid power.

Overall, the conflict has exacerbated the already critical energy crisis in Lebanon, highlighting the urgent need for comprehensive recovery and reconstruction efforts to restore and enhance the country's energy infrastructure.

Renewable Energy Sector

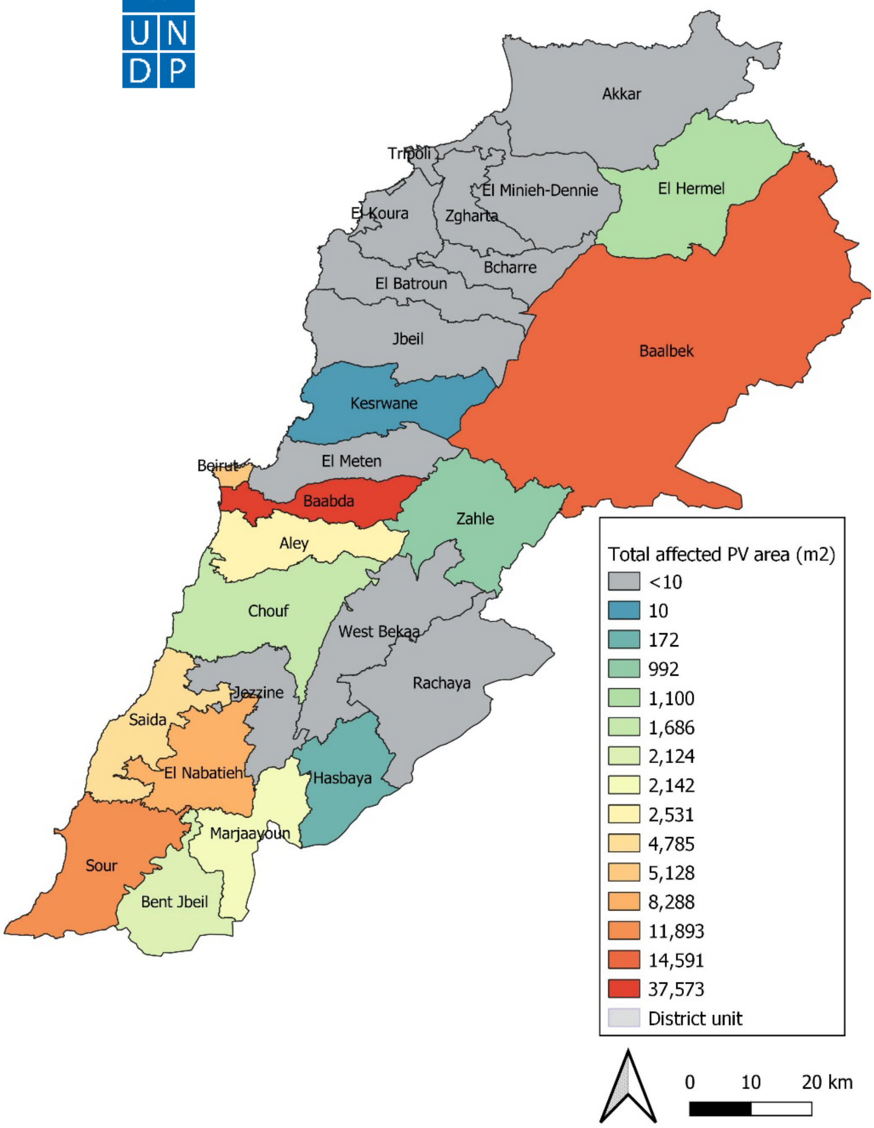
Lebanon has experienced a rapid surge in solar energy adoption since 2020, driven by the country's ongoing electricity crisis and the urgent need for reliable and sustainable alternatives. By 2023, the nation had achieved a cumulative installed photovoltaic (PV) capacity of 1,253.98 MWp, encompassing both utility-scale projects and distributed solar systems across households, businesses, and agricultural operations. Key districts that emerged as hubs for solar installations include Baalbek, Zahle, Saida, Baabda, and El Metn, with significant contributions from coastal and agricultural regions.

However, the recent conflict severely disrupted this progress, particularly in the southern regions of Lebanon. The assessment identified damage to distributed solar PV installations, with 2,751 units confirmed as damaged, covering a total area of 93,016 m^2, around 1.4% of total solar PV area in Lebanon. This damage resulted in a loss of energy capacity, amounting to 14.9 MWp, which translated into an estimated 21,289.62 MWh of lost energy generation. The most affected districts included Baabda, Baalbek, Sour, and El Nabatiyeh, where the destruction of PV systems had a profound impact on local energy production and reliability as shown in Figure 15 below. In these areas, minor blast effects, debris accumulation, and shockwaves caused additional damage to multiple installations, intensifying the energy shortfall. The conflict's impact on solar energy infrastructure was particularly severe in the southern regions, where many PV installations were located. Damage to these systems not only disrupted energy supply but also increased reliance on expensive and environmentally harmful diesel generators. This shift exacerbated operational costs and pollution levels, reversing the progress made toward sustainable energy resilience in Lebanon. Additionally, the loss of decentralized solar power heightened Lebanon's ongoing energy crisis, making urgent recovery efforts essential to restore sustainable electricity access and economic stability.

In addition to the direct damage to PV installations, the conflict also affected the broader energy sector, including transmission and distribution networks. The transmission network and substations sustained significant damage, disrupting electricity supply primarily in El Nabatiyeh, Baalbek-Hermel, and the South governorates. At the distribution level, damage was widespread, affecting MV substations, MV/LV distribution networks, and underground cables, particularly in Beirut's southern suburbs.

Overall, the conflict has posed a significant setback to Lebanon's renewable energy transition, particularly distributed solar PV systems, highlighting the urgent need for comprehensive recovery and reconstruction efforts to restore and enhance the country's solar energy infrastructure. Immediate repairs and targeted investments are essential to rebuild resilient PV systems and ensure sustainable energy access in conflict-affected regions.

Figure 17: Distribution of Damaged PV Panels per District.



Economic and Social Impact

The destruction of PV systems led to substantial economic losses and service disruptions. Households, businesses, and agricultural operations that relied on solar power faced increased power outages and higher energy costs, forcing many to revert to expensive and environmentally harmful diesel generators. This heightened dependence on diesel not only increased operational costs but also exacerbated pollution levels, reversing progress made toward sustainable energy resilience in Lebanon. Numerous agricultural solar PV projects were initiated with the support of USAID in the southern region and the Bekaa Valley. However, many of these projects have been halted due to the ongoing conflict in 2024 and the new US administration[57]. Moreover, USAID has funded 41 solar energy projects, benefiting 460,000 residents across 70 towns and villages in Lebanon. Besides supplying essential electricity, these solar-powered water pumping projects also upgrade the chlorination equipment at the stations[58].

These energy shortfalls disrupted service provision across various sectors, forcing many communities and businesses to revert to expensive and environmentally harmful diesel generators. The heightened dependence on diesel not only increased operational costs but also exacerbated pollution levels, reversing progress made toward sustainable energy resilience in Lebanon. The economic impact extended beyond direct energy losses, affecting livelihoods, agricultural productivity, and business continuity, particularly in districts with high PV system density, such as Baabda, Sour, and Baalbek. In these regions, even minor blast effects, debris accumulation, and shockwaves damaged multiple installations simultaneously, further amplifying the energy deficit. As a result, the loss of decentralized solar power amplified Lebanon's ongoing energy crisis, making urgent recovery efforts essential to restore sustainable electricity access and economic stability.

Recovery and Reconstruction Needs

The recovery and reconstruction needs for the power sector are estimated at US$ 146.88 million. This includes US$ 127 million for the rehabilitation of transmission and distribution networks and US$ 20 million for service delivery restoration, design, engineering, and technical assistance. Immediate repairs should prioritize the restoration of PV systems in the most affected districts, adopting resilient designs for future installations and allocating recovery funds based on damage severity and energy needs.

Rehabilitation of transmission and distribution networks:

- Transmission Network: Repair and restore Medium Voltage (MV) and High Voltage (HV) equipment, transformers, and mobile substations.
- Distribution Network: Rebuild MV/LV substations, MV and LV distribution networks, including poles, cables, switchgears, transformers, distribution panels, electrical accessories, and underground cables (UGC).

Service delivery restoration:

- Design, Engineering, and Operational Service Restoration: Implement comprehensive design and engineering solutions to restore operational services.
- Technical Assistance and Capacity Development: Provide technical assistance and capacity-building initiatives to enhance the skills and capabilities of the workforce involved in the power sector.

57 Study done by the USAID.

58 Twenty-two new solar projects were announced in different villages in Lebanon prior to the 2024 war.

Short-term recovery needs:
Focus on restoring 50% of the distribution assets and 30% of the transmission assets within the first 12 months.

Medium-term recovery needs:
Complete the remaining 50% of distribution assets and 70% of transmission assets over the next two to three years.

Long-term recovery needs:

Continue technical assistance and capacity development efforts beyond the initial recovery phases to ensure sustainable improvements in the power sector.

These reconstruction needs aim to address the extensive damage to Lebanon's power infrastructure, ensuring the restoration of reliable electricity supply and enhancing the resilience of the power sector.

4. MODELLING OF WIND ENERGY, SOLAR PV AND HYDRO POWER PROMOTION IN LEBANON

4. Modelling of Wind Energy, Solar PV and Hydro Power Promotion in Lebanon

This section describes the DREI modelling for promotion of private sector, large-scale investment in wind energy, solar PV and hydro power and distributed solar PV[59] in Lebanon. First, a summary of the approach to the modelling is provided. It describes the two scenarios modelled, highlighting key modelling assumptions and setting out the underlying risk categories, as well as the associated barriers and public instruments[60]. It then describes the modelling results, organized in terms of the DREI methodology's four stages.

As in any modelling exercise, the modelling uses a simplified set of underlying data and assumptions that are presented in Annex A. 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 Lebanon

In order to study different public instrument packages, the modelling compares two core scenarios to achieve the envisioned 2030 investment targets for large-scale wind energy, solar PV, hydro power and distributed solar PV including storage and excluding storage: a business-as-usual (BAU)[61] scenario and a post-derisking scenario. Both scenarios take today's (2025)[62] risk environment in Lebanon as the starting point, while the study period for the financial modelling is set to be from 2025 to 2030 (5 years).

- **Business-as-usual (BAU) scenario.**
  - This scenario assumes that the envisioned 2030 renewable energy investment target is achieved under today's risk environment in Lebanon.
  - The BAU scenario uses the current financing costs and terms (capital structure and loan tenor) that an investor encounters in Lebanon.
  - As of 2025, MoEW has plans to build new traditional power plants and also focus on renewable energy investments[63].

59 The solar PV mini-grid is designed to serve a small village in Lebanon, providing reliable and sustainable electricity to approximately 80 end users. The system will supply power to households, a municipal building, a school, a clinic, and street lighting infrastructure, covering essential community needs. The mini-grid aims to enhance energy access, reduce reliance on diesel generators, and support local development through clean and affordable electricity.

60 Risks and instruments used for utility scale and distributed scale are similar in nature in the Lebanese context and confirmed after interviews with stakeholders.

61 The BAU scenario incorporates the assumed demand of 21,856 GWh, which reflects the current situation in Lebanon with a increase of 1% year on year until 2030.

62 Data collection has been performed in spring 2025.

63 Officials have announced plans to construct a gas station that will also emphasize green energy initiatives.

- **Post-derisking scenario.**
  - This scenario assumes that the envisioned 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 BAU 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.

The following key issues associated with the modelling merit highlighting:

- **Variability.** An inherent characteristic of wind energy, solar PV (utility scale and distributed) and hydro power 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. The assumed targets anticipate that wind energy, solar PV (utility scale and distributed) and hydropower will be around 26%[64] of Lebanon's projected electricity demand under the MoEW permits and arguably this level can be absorbed into Lebanon's power grid with minimal cost or disruption.
- **Transmission Lines.** In order to keep the modelling manageable, the modelling assumes that all the wind energy, solar PV (utility scale and distributed) and hydro power sites to meet the envisioned 2030 investment target are within 10 km of the existing grid for utility scale and 1 km from the distributed solar PV projects. Capital costs related to the upgrade and maintenance of the grid infrastructure in Lebanon are excluded from the analysis.

- **Baseline approach.**
  - Renewable energy investments are made in the context of an existing or evolving electricity generation mix. Lebanon economic crisis has led to increased consumer awareness and behavioural changes; therefore, it is estimated that average demand now reaches approximately 21,856 GWh. While overall energy consumption has declined, driven by both efficiency measures and the broader economic downturn, long-term energy behavior indicates sustained demand and a growth of 3% yearly. Consequently, new wind, solar PV and hydro installations will likely not replace existing capacity. Nevertheless, Lebanon's existing power plant fleet is old and inefficient. Despite the ongoing refurbishment campaign by the GoL, it can be anticipated that new RE installations could at least partly replace the existing fleet[65].

64 Taking into account that Lebanon will have a demand of 21,856 GWh by 2030 with 5,735 GW expected from RE.

65 In other words, renewable energy will be an addition to the existing fleet and will replace outdated old plants with a very low efficiency.

- Private-sector financing costs are used to finance Renewable energy projects. This reflects an assumption that Lebanon is seeking to attract private sector investment irrespective of the energy technology.
- The baseline mix approach for utility scale: The modelling assumes a combined baseline grid emission factor equating to 0.691 tonnes of CO_2e/MWh. This is also calculated based on the emission factors of the existing plants adding private power generation i.e., private generators and distributed solar PV. This will be elaborated in the assumption of energy mix baseline below (Section 4.2.1)[66].
- The baseline mix approach for mini-grid solar PV: In order to compare the effect of the lowered financing cost on the life-cycle cost of an investment using the DREI (mini-grid) study, the methodology calculates the LCOE of solar mini-grids and compares it to the LCOE of a baseline technology, that is a diesel-powered mini-grid. The model does not consider any other mix and is strictly compared to the generator LCOE based on the model provided by UNDP. At the generic Lebanese village level, a diesel generator is assumed to be the baseline. The sizing is therefore done for both the baseline and the renewable energy technology, solar PV with battery storage and without storage. The diesel generator is sized to meet the peak demand at all times, and the solar PV and battery are sized to meet the peak demand as well as the daily energy consumption with at least 95% reliability for 6 hours. Two scenarios are considered, one with storage and a capacity of 1,200 MW and the second without storage and with capacity of 1,200 MW. The LCOE in both scenarios accounts for the technologies themselves, but does not include the additional demand gap that arises when solar PV and batteries are not operational. Moreover, in our model for the solar mini-grid, we assume that light-touch regulations are in place.

- **Unsubsidised baseline fuel costs.** The fuel costs have been obtained from World Bank projections for the gas price and from Energy Information Agency projections for diesel and heavy fuel oil prices[67]. These fuel costs are fully unsubsidized. More broadly, issues related to the subsidization of existing power generation in Lebanon, whether through fuel import subsidies or non-cost-reflective tariffs, are outside the scope of this analysis and were not incorporated into the modelling, as the Ministry has removed all subsidies.
- **Installed costs and O&M costs for wind energy, solar PV (utility and distributed) and hydro power.** The assumptions for the installed costs (i.e. the cost of hardware, such as wind turbines and solar panels) and for the operations and maintenance (O&M) costs have particular potential for improving the overall competitiveness of wind energy, solar PV (utility and distributed) and hydropower in Lebanon. Globally, the costs of renewable energy hardware have been falling consistently over time, and they are expected to continue to do so specifically for solar PV. The same is true for O&M costs, which is partly due to technology improvements and better forecasting, and partly also due to the increasing competition for O&M contracts as the number of service providers keeps growing. This study assumes installed and O&M costs for onshore wind energy, solar PV and run-of-river hydropower expected to

66 Source: IGES GRIS EF 2025; Lebanon BUR4 2021 Summary of GHG emissions in Lebanon (0.672 tCO_2e/MWh, including hydropower and solar PV); Statistics from Ministry of Water and Energy (2023) for operating power plant fleet emission factor.

67 Energy price are as of June 2025. Today in Energy Daily Prices - U.S. Energy Information Administration (EIA)

prevail at the end of the year 2030. The Detailed O&M cost are reflected in the Annex. The sensitivity analysis that is part of this DREI study will elucidate the impact on the results when assuming today's (2025) installed and O&M costs as provided by Lebanese developers and market price. The Solar PV O&M is assumed the same.

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

4.1.3 Public Instrument Table

The following Table 5 sets out in full the stakeholders, barriers and risk categories for large-scale wind energy, solar PV, hydro run-of-river, and distributed solar PV (with storage and without)[68] and the matching public instruments to address these barriers and risks. This was derived from the generic public instrument table for large-scale, renewable energy in the DREI report (Waissbein et al., 2013) and the DREI report for mini-grid solar PV (Waissbein et al., 2018). Due to the dynamic shift in Lebanon between 2019 and 2025 and based on stakeholder consultation and investors' feedback, a number of changes have been made to the generic table; these changes are added in table 5 and described in Annex A.

Moreover, while gender-responsive public instruments were initially considered during the early scoping phase of this assessment, consultations with UNDP and discussions with investors and energy sector stakeholders concluded that such instruments were not directly relevant to the context of de-risking renewable energy investments in Lebanon. The energy sector, particularly utility and mini-grid development is primarily infrastructure- and technology-driven, with limited gender-differentiated access, participation, or impact at the investment level. The key barriers identified by investors, such as regulatory uncertainty, grid access limitations, and financial risk, apply uniformly across market actors regardless of gender. As such, gender responsiveness was deemed unnecessary for the scope and objectives of this analysis.

68 Given the risk landscape in Lebanon, the risks associated with distributed solar PV mini-grids are largely similar to those of utility-scale distributed systems. Therefore, for simplicity, they are presented together in a single table.

Table 5:Risks, barriers, and public instruments table (Part I).

RISKS AND BARRIERS				MENU OF SELECTED PUBLIC INSTRUMENTS			
				Policy Derisking Instruments		Financial Derisking Instruments	
Risk Category	Description	Underlying Barriers	Key Stakeholder Group	Activity	Description	Activity	Description
1. Power Market Risk	Risks 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*: Ineffective PPA tendering process, inability to evaluate Solar PPA tenders	Public sector (GoL, Parliament, Concerned ministries)	Streamline RFP process, standardize contract templates, enable regulatory framework support	Implementing a transparent and streamlined Request for Proposal (RFP) process can enhance project transparency and accountability. Providing standardized templates for solar and wind PPAs can ensure consistency and clarity in contract terms, reducing the time and cost associated with contract development. Establishing a supportive regulatory framework that includes long-term, legally binding renewable energy targets and enabling policies can create a more favorable environment for PPA tenders.	-	-
		- *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 *Lack of calirty on payment mechanisms by EDL; Non-cost-reflective tariffs with a flat rate for all regions*		Establish a harmonized, well-regulated and unbundled energy market, with cornerstone instruments to address price and market-access risk for renewable energy projects *Incorporating international and independent arbitration mechanisms in contracts with off-takers to provide a reliable and impartial process for resolving disputes, thereby enhancing investor confidence and mitigating legal risks* *Implement a floating, cost-reflective tariff mechanism to ensure tariffs are aligned with actual costs in different areas, e.g: Bekaa irradiation is much higher than South, with increased PV output efficiency*	(i) Ongoing legislative reform (Law 462, together with Laws 288, 54and 318) to implement well-dsigned and harmonized policies, including establishment of the National Electricity Regulatory Authority (NERA) and unbundling of the energy market (generation, transmission, distribution); ii) Implement RE law 318/2023 fully ; iii) Implement FiT and PPA tendering, including well-designed standard PPA	-	-
		- *Market distortions:* EDL single buyer model; increased reliance on private generators specially in affect post-war areas		Transition to bilateral contracts Model with an independent regulatory authority; Draft exit plan for private generators *Activate and fully implement new initiatives under Law 318, enabling private sector entities to trade energy directly on a peer-to-peer basis, thereby mitigating risks associated with the single buyer model*	Transitioning from the single buyer model to a bilateral contracts model where producers can directly contract with distributors and consumers. Implementing long-term power purchase agreements (PPAs) with purchase guarantees or capacity payments to secure revenue for producers irrespective of the energy delivered. Offering financial incentives such as grants, concessional loans, and tax breaks for private generators to invest in Commercial and industrial (C&I) renewable energy projects	-	-
2. Permits Risk	Risks 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 licenses and permits (generation, EIAs, land title) for renewable energy projects	Public sector (MoEW , MoE, MoF, other ministries might be involved)	Set up a the National Electricity Regulatory Authority to Streamline processes for permits	Establish a one-stop-shop for renewable energy permits with clear accountability and appropriate expertise for renewable energy under ERA supervision; harmonisation of requirements; training of one-stop-shop staff in renewable energy	-	-
		- High levels of corruption; No clear recourse mechanisms.		Contract enforcement and recourse mechanisms with a clear framework	Enforce transparent practices, renewable energy related corruption control and fraud avoidance mechanisms; establish effective recourse mechanisms	-	-
3. Social Acceptance Risk	Risks arising from lack of awareness and resistance to renewable energy in communities, among end-users, and private generators	- Lack of awareness of renewable energy amongst consumers, end-users, local residents, and labor unions	End-users, general public, private generators, Public Sector (Ministry	Awareness-raising campaigns targeting communities and end-users	Working with the media, awareness campaigns, stakeholder dialogue and workshops with end users, policymakers, and local residents.	-	-
		- Social and political resistance related to NIMBY concerns, special interest groups *Negative sentiment towards Independent Power Producers (IPPs) and private sector involvement in the energy market in particular if not affiliated to a political and regional context*		Pilot models for community involvement at project sites *Transition plans for public workers in the energy sector who might lose their jobs with privatization* *Develop plans for potential ownerships of RE projects by local communities (e.g. through municipalities union or Federation of Municipalities at a Casa level)*	Community consultations including piloting models such as in-kind services (energy access, local employment; etc.) or equity stakes in renewable energy projects	-	-
		- Post-war displacement		Fair compensation and resettlement plans	Develop and implement fair compensation and resettlement plans that provide adequate housing, livelihood opportunities, and social services for displaced communities along with RE projects plans	-	-
		- Social and political resistance related to the (shadow) business of operating private generators during power outages		Security concepts for project sites, law enforcement, pilot models for stakeholder involvement at project sites	Ensure the deployment of security plans to prevent sabotage, enforce existing laws to protect assets/prevent shadow business , Community consultations including piloting models such as in-kind services (energy access, local employment; etc.) or equity stakes in renewable energy projects	-	-
4. Developer 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	Project developers, Ministry of Industry, Lebanese Standards Institution, Technology supplier	For wind energy only: building capacity for resource assessment	For wind energy only: Capacity building and dissemination of top-level, national resource assessment findings; grant funding for on-site resource assessment	-	-
		- *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.); Access to grid not guaranteed; lack of skilled and experienced local workforce due to economic crisis and conflict		Via ERA: feasibility studies; networking; training and qualifications; technology and O&M assistance; grid connectivity guarantees; incentives for highly skilled individual; Capacity building for labors	Industry conferences; grant funding for pre-feasibility studies (depending on technology); training, apprenticeships and university programmes to build skills (planning, construction, O&M); focus on building access to grid; Implement incentives to attract highly skilled individuals to return and work in Lebanon, thereby enhancing the talent pool and expertise available for renewable energy projects; Build the capacity for labors in the energy sector to meet world class renewable energy standards	-	-
		- *For the purchase of hardware*: purchaser's lack of information on quality, reliability and cost of hardware; lack of local industrial presence and experience with hardware (suitability of hardware to local climatic and physical conditions),		Research and development; technology standards; exchange of market information, *Adopt and enforce clear hardware quality selection criteria based on the Lebanese Standards Institution (LIBNOR) guidelines to ensure quality control - Solar PV standards are being updated and included in the LIBNOR guidelines;* *Enforce a thourough custom application to reduce smuggling and maintain a fairly competitive landscape*	Test centre for research and development into long-term quality of equipment; capacity building for definition and implementation of standards including tests and inspection; awareness campaigns and trade fairs;	Financial products by development banks to assist manufacturers in gaining access to capital/funding	Depends on specific financial circumstances. Can include as necessary: public loans; public loan guarantees; public equity

Source: Authors; Stakeholder interview (2025); Adapted from Derisking Renewable Energy Investment (Waissbein et al., 2013).

Table 5: Risks, barriers, and public instruments table (Part II).

RISKS AND BARRIERS				MENU OF SELECTED PUBLIC INSTRUMENTS			
				Policy Derisking Instruments		Financial Derisking Instruments	
Risk Category	Description	Underlying Barriers	Key Stakeholder Group	Activity	Description	Activity	Description
5. Grid/ Transmission Risk	Risks arising from limitations in grid management and transmission infrastructure in the particular country	- *Grid code and management:* limited experience or suboptimal operational track-record of grid operator with intermittent sources (e.g., grid management and stability). Lack of standards for the integration of intermittent, renewable energy sources into the grid; Limited awareness and lack of implementation of Law of Electricity Sector Organization 461/2002 and Renewable Energy law 318/2023	Électricité du Liban (as transmission/ grid operator) Public sector (ministry of finance, Ministry of energy and warter)	Strengthen EDL's operational performance, grid management and formulation of grid code; implement fully Law of Electricity Sector Organization 461/2002 and Renewable Energy law 318/2023	Dissemination of grid code developed by DREG and CEDRO projects (MoEW), including procedures to connect new RE infrastructure to the grid; sharing of international best practice in grid management; Implement virtual and single net metering for distributed solar PV	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)
				Facilitiate the development and implementation of micro-grid solutions that can eventually connect to the national grid, thereby reducing transmission and operational risks and enhancing the resilience of renewable energy projects;			
		- *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; substantial damage to transmission and distribution networks, including MV substations, MV/LV distribution networks, and underground cables; Price burden on developers for connectivity		Policy support for national grid infrastructure development including fast term release Immediate Repairs and Infrastructure Rehabilitation; build connection substations in war targeted areas;	Develop and regularly update a long-term national transmission/grid road-map to include intermittent renewable energy; Concentrate initial reconstruction on war damaged areas and infrastructure; Enhance collection rates to reduce non-technical losses, thereby improving the financial performance	Financial products by development banks to assist EDL in gaining access to capital/funding, secure grants for reconstruction; immediate release of funds for fixing infrastructure damage	Depends on specific financial circumstances. Can include as necessary: public loans; public loan guarantees; public equity, Secure grants for infrastructure damage cost (estimated to be USD 147 million);
6. Counterparty Risk	Risks arising from the utility's poor credit quality and an IPP's reliance on payments	- Limitations in the EDL's (as electricity purchaser) credit quality, corporate governance, management and operational track-record or outlook; unfavourable policies regarding utility's cost-recovery arrangements; Financial strain to repair damaged infrastructure due to on going conflicts	Électricité du Liban (as electricity purchaser)	Strengthen EDL's management/operational performance; enhance bill collection efficiency and phase out energy subsidies	Establish international best practice in EDL's management, operations and corporate governance; implement sustainable cost recovery policies; Adhere to the price margins established by the 3RF meeting and the Ministry for bill collection	Government (sovereign) guarantees or backing for PPA payments; secure gruants to cover infrastructure damage cost	Depends on specific circumstances and division of risks in PPA. Can include, as necesssary: Government letter of support for PPA payments to IPPs (potentially to be endorsed by the council of Ministers); partial risk guarantees on PPA; counterparty guarantees as part of political risk insurance (PRI)
				Contract international power consultant to help EDL manage governance; Ensure grid reliability as per law 462/2002 through ERA, facilitate political risk guarantees, and enforce a stable regulatory framework		*Cost reflective tarrifs, a Partial Risk Guarantee (PRG) structure to help manage credit risk; Strengthen EdL audit process and external management review; revamp EDL governance structure*	
				Enforce comprehensive bill collection across all Lebanese territories and entities to ensure consistent revenue streams and financial stability for renewable energy projects. This includes refugee camps.		*Establish a collection account mechanism with clear, transparent and non-bureaucratic system, managed by an independent credible third party to ensure payments by the offtake; Conduct financial audits to reassure investors of the off-taker's credibility and financial operations*	
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 availability of local or international capital (equity/and or debt) for green infrastructure. Collapse of the financial sector and no capital availability for loans	Investors (equity and debt)	Financial sector policy reforms	Promote financial sector policy favorable to long-term infrastructure, including project finance	Financial products by development banks or the Central Bank, to assist project developers to gain access to capital/funding	Depends on specific financial circumstances. Can include as necessary: public loans; public loan guarantees; public equity; re-introduce the NEERA financing mechanism
						Allow ESCROW accounts outside Lebanon for monetary transactions (for utility scale projects: a neutral third party holds funds on behalf of two parties involved in the Renewable energy development until specific conditions are met); Ensure a credible, transparent and clear mechanism for financial transactions	
		- *Limited experience with renewable energy (utility scale projects):* 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		Strengthen investors' (debt and equity) familiarity with and capacity regarding utility scale renewable energy projects	Industry-finance dialogues and conferences; workshops/training on project assessment and financial structuring (project finance); public-private partnership building	*Implement reforms for the financial sector; allow or provide guarantees for free access to capital in Lebanese financial institutions invested in RE projects*	
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)	Investors (equity and debt), Public sector	Security guarantees for investors	Strengthen national security frameworks for energy infrastructure	Risk sharing products by development banks to address political risk, Political risk insurance for foreign investors	Provision of political risk insurance (PRI) covering (i) expropriation, (ii) political violence, (iii) currency restrictions, (iv) Coverage for unexpected geopolitical disruptions
						Political Risk Insurance (PRI) to cover local investors, as Multilateral Investment Guarantee Agency (MIGA) Cover only international investors; Implementing insurance policies, including war insurance and credit insurance	
		- Change of political administration in Lebanon		Strengthen long-term policy commitment to Renewable Energy Projects	Develop a comprehensive national energy transition plan that outlines clear goals, timelines, and strategies for transitioning to renewable energy	Public-private partnerships for Renewable Energy development	Engage private investors in large-scale renewable energy projects to leverage private capital and expertise, enhancing project scale and impact.
		- Withdrawal of international aids from Lebanon e.g: USAID, IMF, WB, etc...		Plan for alternative funding sources	Develop a strategic plan to identify and secure alternative funding sources for renewable energy projects. This plan should explore various avenues such as international grants, private sector investments, public-private partnerships, and crowdfunding initiatives. The plan can reduce dependency on traditional financing methods and enhance the financial resilience	Diversify funding through blended finance	Utilize a mix of grants, concessional loans, and equity investments to finance renewable energy projects. This diversified approach can provide flexible funding options, reduce financial risks, and enhance the overall attractiveness of investments.
						Issue memos and/or special legislations on a project basis to ease the development and implementation	
						Revise and reform laws to better fit RE projects EPC cycle	
9.Currency/ Macro-economic Risk	Risks arising from the broader macroeconomic environment and market dynamics	- *Currency Volatility and Depreciation:* Persistent fluctuations in the local currency and unfavorable exchange rate movements impacting investment returns.	Investors (equity and debt), Public sector	-	-	Risk sharing mechanisms to address currency risk (excluding private sector instruments such as hedging, interest rate swaps)	Partial indexing of local currency tariffs in PPAs, so that IPPs are reimbursed for local currency depreciation of tariff
						Develop laws and contracts to dollarize transactions between off-takers and energy producers, incorporating official fluctuating exchange rates (fully indexing) in agreements such as Power Purchase Agreements (PPAs) to ensure financial stability and predictability	
		- *Macroeconomic Instability and Inflation:* Uncertainty around inflation, high-interest rates, and liquidity issues due to government fiscal instability and restrictions on foreign currency transactions.		-	-	Government-backed credit lines and financial guarantees	Ensure capital availability and investor confidence through public financial instruments
						Develop laws and contracts that include provisions for international arbitration, involving an impartial tribunal or panel to examine facts and render binding decisions based on arbitration agreements between the parties.	
		- *Foreign Exchange Constraints and LBP Devaluation:* Dependence on a cash economy, restrictive USD transaction policies, and expected further devaluation of the Lebanese Pound (LBP).		*Consider a tax reduction framework for renewable energy to attract foreign capital and enhance the financial viability of projects.*		Establish hedging mechanisms backed by international financial institutions	Provide financial tools for mitigating foreign exchange risks and supporting energy sector investments
10.Climate Risk	Risk arising from change in water precipitation and droughts in Lebanon	-Climate effect on precipitation and water quantity for hydropower	Public Sector (Ministry of Energy and Water)	Implement low climate impact technologies and streamline climate impact assessment for projects	Encourage investment in hydropower technologies resilient to climate variability and droughts	Financial incentives for climate-resilient projects	Provide grants, concessional financing, and subsidies for hydropower projects implementing climate adaptation measures

Authors; Stakeholder interview (2025); Adapted from Derisking Renewable Energy Investment (Waissbein et al., 2013).

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 19 project developers, investors and loan providers who are domestically and internationally active and who are considering, or are actively involved in, large-scale wind, utility and distributed solar PV and hydro power investment opportunities in Lebanon and abroad. Most of the interviews were held face-to-face during a country mission at end of March 2025. A few interviews were held remotely early March 2025. In addition, informational inquiries were placed in person during the country mission and in writing throughout the analytical work to the interviewees and other stakeholders.

Financing Cost Waterfalls

The analysis of the contribution of investment risks to higher financing costs in Lebanon is shown in the financing cost waterfalls in Figure 18 and 19 compared to best-in-class and best-in-region countries respectively. This analysis was performed jointly for wind energy, utility and distributed solar PV and hydro power investors. Definitions of each of the risk categories can be found in Table 5.

The qualitative component of the stakeholder interviews provided valuable insights into the perceptions, concerns, and expectations of developers and investors regarding renewable energy investments in Lebanon. Beyond the numerical scores used in the DREI modeling tools, participants shared detailed views on the ten key risk categories, their perceived financial impact, and the effectiveness of the public de-risking instruments aimed at mitigating these risks. A summary of the qualitative feedback that wind energy, solar PV and hydro power developers and investors shared in their interviews is provided in Table 6.

The results estimate the business-as-usual cost of financing in Lebanon today for wind energy and solar PV to be 26%[69] for the cost of equity (CoE) and 13% for the cost of debt (CoD)[70]. These are substantially higher than in the best-in-class and best-in-region countries, Germany and Jordan, which is estimated respectively at 8.0% and 13.0% for the CoE and 4.0% and 7.0% for the CoD. Five risk categories-permit risk, currency risk, counterparty risk, financial sector risk and political risk–all have a high impact on financing costs. Climate risk is attributed solely to hydro power projects as it addresses precipitation levels. As is shown in later results, over the long lifetime of energy investments, the impact of Lebanon's higher financing costs on the competitiveness of renewable energy is substantial.

The selection of the best-in-class country and best-in-region country is elaborated in Annex A[71]. Moreover, the results of CoE for Lebanon is derived from the CapM model, the result of CoD is acquired from interviews with debt providers. As for the financing capital and structure for Germany and Jordan,

69 CoE is based on the CapM model calculation.

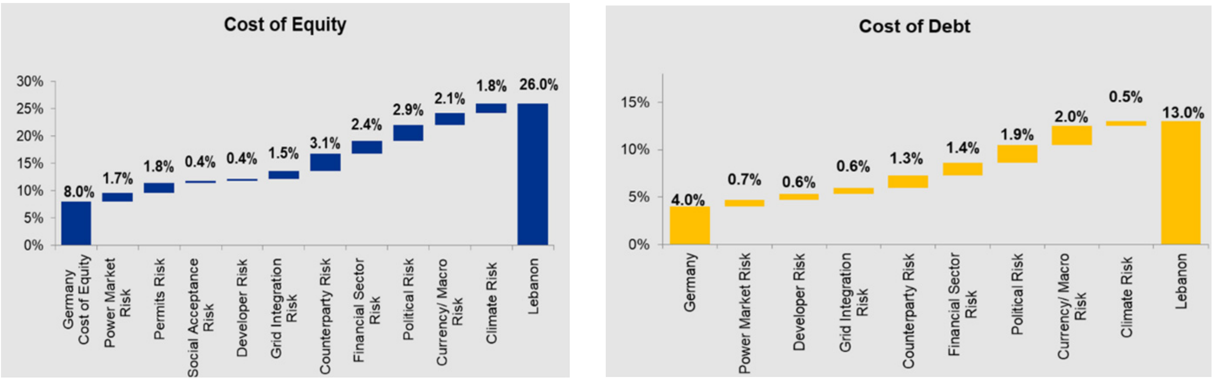
70 CoE and CoD are USD-denominated.

71 A matrix was created by KPMG to choose the best-in-region comparing different data point such as proximity in climate, culture, politics, economy, size etc.

interviews were held with renewable energy stakeholders from each country where the CoE and CoD was provided.

Figure 18: Impact of risk categories on financing costs for wind energy, solar PV (utility and distributed) and hydro power investments in Lebanon, business-as-usual scenario (Germany)[72].

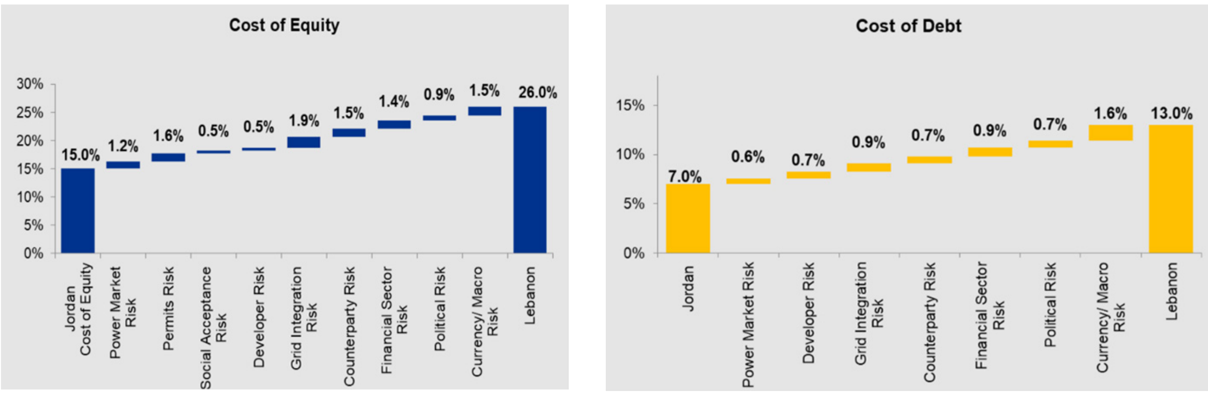
Business-as-Usual Financing Costs



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

Figure 19: Impact of risk categories on financing costs for wind energy and solar PV (utility and distributed) investments in Lebanon, business-as-usual scenario (Jordan)[73].

Business-as-Usual Financing Costs



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

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72 The financing cost waterfalls shown here are calculated by differentiating between the answers from equity and from debt investors but not distinguishing further between investors with focus on wind energy, investors with focus on solar PV (utility or distributed) and investors focused on hydro power. It is recognized that the risk profiles of wind energy, solar PV and hydro power can differ. However, the results of the interviews with wind energy, solar PV and hydro power investors made clear that these differences are minimal in the Lebanese context. As such, the interview answers from equity and from debt investors were not further split into 'wind energy focus', 'solar PV focus' and 'hydro power focus' sub-groups, in order to bring simplicity to the analysis and to avoid multiple result sets. For comparison, cost waterfalls with a distinction between answers from wind energy, solar PV and hydro power investors are shown in Annex A.

73 In the context of Jordan, hydro power is not considered in this study as it's potential is limited, primarily due to a lack of large, suitable bodies of water for large scale hydro-electric power. Lebanon has a better established infrastructure with higher potential of hydro power.

Table 6: Qualitative investor feedback on risk categories for wind energy, solar PV and hydro power investment in Lebanon.

Risk Category	Investor Feedback
Power market risk	This risk category is perceived as medium to high in its impact on financing. While there is optimism about Lebanon's renewable energy potential and some openness in the market, major concerns remain around ineffective PPA tendering process, lack of a clear framework for Independent Power Producers (IPPs), and the continued dominance of the EDL single-buyer model as major impediments. Private sector developers struggle with unclear pricing, absence of enforceable frameworks, and political interference, particularly for utility-scale projects. Law 318 shows promise but lacks clear implementation and oversight. As for distributed Solar PV and mini-grids, a restriction in peer-to-peer distribution beyond adjacent plots is seen as a risk pushing the power market risk higher.
Permits risk	Permitting is widely considered a very high-risk, particularly for utility-scale projects. Developers face prolonged delays due to complex, bureaucratic processes involving multiple ministries, overlapping jurisdictions, and unclear regulatory responsibilities. Legal uncertainties around land titles, instances of corruption, and inconsistent interpretations of regulations further compound the problem. Municipal disputes and the need for ministerial-level approvals often stall projects indefinitely, creating both cost overruns and investor uncertainty.
Social acceptance risk	This risk category is perceived as a low risk with minimal impact on the cost of financing. Most investors consider the level of problem awareness among the people of Lebanon quite high, owing to the notorious under-supply. Public support for renewable energy, especially solar PV is relatively strong, driven by the chronic undersupply of electricity in Lebanon. However, concerns were raised for wind energy projects, particularly around environmental issues such as bird migration routes.
Developer Risk	This risk category has a low to medium impact on financing cost. Investors are confident about the availability of good companies and qualified personnel in Lebanon. There are strong local technical and engineering capabilities, particularly in solar PV. Most developers are confident in managing technical risks internally, including EPC, O&M, and resource assessment. However, wind energy projects face challenges related to logistics and road access, increasing costs. Legal ambiguity around hardware ownership in case of disputes (not clear in law 462 or law 318) and land use complications for utility-scale projects were noted as lingering issues. Securing the land was mentioned to be challenging in Lebanon, especially along the densely populated coast and in regions with especially complex political structures. Developers also showed concern regarding tax on hardware.
Grid integration risk	This risk category has a high impact on financing costs. The current condition of the grid and its management (incl. the lack of robust grid codes) is perceived as a major threat and has a direct impact on project bankability. The existing grid is outdated, unreliable, and inadequately maintained. Furthermore, several investors expressed concerns that EDL would lack the budget to perform preventive maintenance but noted that the new tariffs might tip the balance positively for EDL. Developers also mentioned that frequent blackouts, limited capacity for integrating new generations, and challenges are tied to EDL's operational structure. Constraints include a lack of grid codes, metering infrastructure, and long-term transmission planning.

Counterparty risk	Counterparty risk is considered a very high and persistent barrier to investment, particularly for projects relying on EDL as the off taker. The risk stems from EDL's financial instability, delayed or incomplete payments, and weak contract enforcement mechanisms. None of the investors consider EDL to be a trustworthy counterparty and asserted the implementation of the electricity law 318/2023 article 4 that allows multiple electricity off-takers. The bigger concern for most investors is the likelihood of receiving delayed payments, which would add substantially to their risk if EDL will be the only off-taker.
Financial sector risk	Financial sector risk in Lebanon is considered very high due to the collapse of the banking system, limited access to foreign debt, and ongoing economic instability. Local banks lack both the appetite and capacity to support long-term renewable energy project financing, and repayment in Lebanese pounds (LBP) is widely viewed as unreliable. The sector also has limited experience with project-based lending, which is the preferred financing structure for large-scale RE projects in most parts of the world, leading to a reliance on equity-based investments with short payback periods. However, many viewed that project financing experience can be acquired in a fast pace specially with experienced Lebanese financiers with international exposure.
Political risk	Political risk is considered the highest and most difficult among investors. Issues include political instability, war risk, lack of transparency, and weak institutional capacity. The absence of a functional regulatory authority for the energy sector further compounds this risk because the sector is politically driven. Delays in implementing key laws (e.g., Law 318 and 462) and inconsistent government support make long-term investments difficult. Moreover, highest concerns are raised regarding the security status in the region after the 2024 November war in Lebanon; security challenges are fundamental for investors. Changes in the region have a significant effect on the political risk, with many investors mentioning that stability is very much needed to mitigate risks. However, most investors and stakeholders are optimistic with the new administration in place, they are looking forward for foundational changes like forming the ERA and implementing the electricity laws.
Currency/ macroeconomic risk	Currency and macroeconomic instability remain major challenges. While many projects are structured in USD, enforceability in case of payment disputes or bankruptcy remains uncertain. Stakeholders pointed to legal risks if repayment is demanded in LBP despite contracts in USD. Inflation, liquidity issues, and exchange rate volatility continue to affect financing structures.
Climate risk	Considered a low risk as climate concerns are mostly relevant for hydropower projects, due to variability in precipitation and water availability. Hydro power investors concerns are low because it is considered that water volumes will remain the same and needs centuries to change.

Source: interviews with investors (equity investors/developers and debt investors).

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 18 and Figure 19) identify an incremental financing cost for a particular risk category, then the matching public instrument is deployed as part of the public instrument package. Table 5 lists the public instruments in full detail, while Table 7 below provides a summary.

Table 7: The selection of public instruments to achieve the envisioned investment targets for wind energy, solar PV and hydro power.

Risk Category	Policy Derisking Instruments	Financial Derisking Instruments
Power Market Risk	• Streamline RFP process and standardized contracts. • Establishment of an enabling regulatory framework. • Transition to bilateral contract model with an Independent regulatory authority. • Exit plan for private generators and replaced Solar PV mini-grids.	NA
Permits Risk	• Streamlined process for RE permits through ERA. • Contract enforcement and recourse mechanisms.	NA
Social Acceptance Risk	• Awareness-raising campaigns. • Stakeholder outreach, including operators of private generators. • Fair compensation and resettlement plans. • Security concepts for project sites.	NA
Developer Risk	• Capacity building for resource assessment (wind only). • Via ERA: feasibility studies; networking; training and qualifications; technology and O&M assistance; grid connectivity guarantees; incentives for highly skilled individual; Capacity building for labours. • Research and development; technology standards; exchange of market information.	NA
Grid/ Transmission Risk	• Strengthen EDL's management/operational performance; enhance bill collection efficiency and phase out energy subsidies.	• Take-or-pay clause in PPA[74]. • Financial products by development banks to assist EDL in gaining access to capital/ funding, secure grants for reconstruction.
Counterparty Risk	• Strengthening EDL's management and operational performance. • Policy support for national grid infrastructure development including fast term release, Immediate Repairs and Infrastructure Rehabilitation; build connection substations in war targeted areas.	• Government guarantee for PPA payments. • Concessional public loans to IPPs. • Secure grants to cover infrastructure damage cost.

74 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.

Financial Sector Risk	• Fostering financial sector reform towards long-term green infrastructure investment. • Strengthening financial sector's familiarity with renewable energy and project finance.	• Financial products by development banks or the Central Bank, to assist project developers to gain access to capital/funding.
Political Risk	• Security guarantees for investors. • Strengthen long-term policy commitment to Renewable Energy Projects. • Plan for alternative funding sources.	• Risk sharing products by development banks to address political risk, Political risk insurance for foreign investors.
Currency/ Macroeconomic Risk	NA	• Risk sharing mechanisms to address currency risk (excluding private sector instruments such as hedging, interest rate swaps). • Government-backed credit lines and financial guarantees. • Establish hedging mechanisms backed by international financial institutions and Fully index PPA contracts to the dollar.
Climate Risk	• Implement low climate impact technologies and streamline climate impact assessment for projects.	• Financial incentives for climate-resilient projects.

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

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

- For wind energy (2030 target: 226 MW), the total public instrument cost (2025-2030) is estimated as being USD 4.3 million in policy derisking instruments and USD 87.2 million[75] in financial derisking instruments.
- For solar PV (2030 target: 330 MW), the total public instrument cost (2025-2030) is estimated as being USD 4.19 million in policy derisking instruments and USD 67.6 million[76] in financial derisking instruments.
- For hydro power (2030 target: 58 MW), the total public instrument cost (2025-2030) is estimated as being USD 3.9 million in policy derisking instruments and USD 23.9 million[77] in financial derisking instruments.
- For distributed solar PV with storage (2030 target: 1,200 MW), the total public instrument cost (2025-2030) is estimated as being USD 4.2 million in policy derisking instruments and USD 82.4 million in financial derisking instruments.

75 Different approaches (e.g., face value, reserve, cost, no-cost) may be taken to costing financial derisking instruments. Here, a cost approach has been taken for the 'take or pay clause in PPA' and 'government guarantee for PPA', totaling USD 27.2m; A reserve approach has been taken for 'public loans' and 'political risk insurance', totaling USD 45.4m. See Section 4.2.4 for sensitivity analyses on costing. See Annex A for details.

76 Different approaches (e.g., face value, reserve, cost, no-cost) may be taken to costing financial derisking instruments. Here, a cost approach has been taken for the 'take or pay clause in PPA' and 'government guarantee for PPA', totaling USD 25.0m; A reserve approach has been taken for 'public loans' and 'political risk insurance', totaling USD 34.3m. See Section 4.2.4 for sensitivity analyses on costing. See Annex A for details.

77 Different approaches (e.g., face value, reserve, cost, no-cost) may be taken to costing financial derisking instruments. Here, a cost approach has been taken for the 'take or pay clause in PPA' and 'government guarantee for PPA', totaling USD 13.6m; A reserve approach has been taken for 'public loans' and 'political risk insurance', totaling USD 18.7m. See Section 4.2.4 for sensitivity analyses on costing. See Annex A for details.

- For distributed solar PV without storage (2030 target: 1,200 MW), the total public instrument cost (2025-2030) is estimated as being USD 4.2 million in policy derisking instruments and USD 39 million in financial derisking instruments[78].

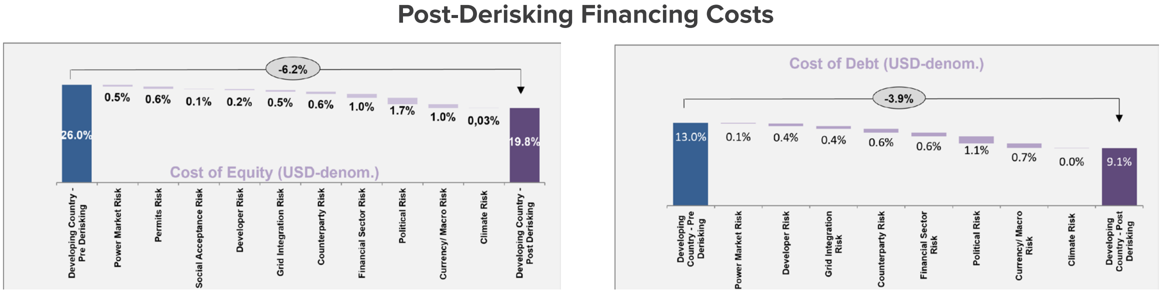
The full breakdown of each selected public instrument and its cost is provided in Tables 14 to 16. Details of the assumptions and the methodology used to generate the cost estimates are available in Annex A.

Impact of public instruments on financing costs

The impact of the public instruments on reducing financing cost for wind energy, solar PV and hydro power in Lebanon are shown in Figure 20[79]. Based on the modelling analysis, the selected package of derisking instruments is anticipated to reduce the average cost of equity until 2030 by 6.2% down to 19.8%, and the cost of debt by 3.9% down to 9.1%.

A brief summary of the qualitative investor feedback on the public instruments discussed in the interviews and on their effectiveness in reducing financing cost in Lebanon is provided in Table 8.

Figure 20: Impact of public derisking instruments on reducing financing costs for wind energy, solar PV and hydro power investments in Lebanon.



Source: interviews with wind energy, solar PV and Hydro power investors and developers; modelling; see Annex A for details of assumptions and methodology. Note: the impacts shown are average impacts over the 2025-2030 modelling period, assuming linear timing effects.

Table 8: Investor feedback on the effectiveness of public instruments to address each risk category in Lebanon.

RISK CATEGORY	PUBLIC INSTRUMENTS	INVESTOR FEEDBACK
Power market risk	Policy derisking instrument(s): Streamline RFP process and standardized contracts, Establishment of an enabling regulatory framework, Transition to bilateral contract model with an Independent regulatory authority, Draft exit plan for private generators.	Policy derisking instruments are highly effective: Interviewees emphasized that streamlining the Request for Proposal (RFP) process and unbundling the energy market would greatly enhance transparency and reduce power market risk. Implementing Law 318 to enable peer-to-peer trading and off-taker diversification was considered essential. Additional suggestions included introducing floating, cost-reflective tariffs tailored to regional solar potential (e.g., Beqaa vs. South Lebanon) and embedding international arbitration clauses within PPAs to strengthen legal enforceability.

78 Indexing to the dollar in the "currency risk" mitigation tool that ensures investor returns are protected from local currency depreciation. It's considered a currency product because it transfers FX risk to a third party, often at a cost. In our model, indexing without storage along with political insurance and debt products costs less because there are no batteries to account for, which are priced in USD — thereby lowering the system's exposure to currency volatility.

79 This includes distributed solar PV cost of equity and cost of debt as the risks are similar in nature and does not differentiate much between utility scale or distributed (mini-grid).

Permits risk	Policy derisking instrument(s): Streamlined process for RE permits through ERA. Contract enforcement and recourse mechanisms.	Policy derisking instruments are highly effective: Interviewees strongly recommend establishing a single empowered regulatory authority, such as the Energy Regulatory Authority (ERA), to oversee and streamline the permitting process. A “one-stop shop” model under this authority would address bureaucratic bottlenecks and legal ambiguity, particularly around land title verification and ministerial overlaps. These reforms were viewed as the most impactful in reducing permitting delays.
Social acceptance risk	Policy derisking instruments: Awareness raising campaigns, community involvement, extra security concepts.	Policy derisking instruments are effective: Community-level engagement was highlighted as a useful tool, especially in municipalities with proactive leadership (e.g., Beit Mery, Baabdat). Suggested instruments include awareness campaigns, transition plans for public employees impacted by privatization, and community ownership models. However, several interviewees noted that awareness of renewable energy is already high, especially after 2019 economic crisis, making the marginal impact of such campaigns limited in many areas.
Developer Risk	Policy derisking instruments: Capacity building for resource assessment (wind only) Via ERA: feasibility studies; networking; training and qualifications; technology and O&M assistance; grid connectivity guarantees; incentives for highly skilled individual; Capacity building for Labours; Research and development; technology standards; exchange of market information.	Policy derisking instruments have limited effect. Most interviewees agreed that developer risk is not significant for solar PV in Lebanon, given the maturity of the local market and the availability of technical expertise. Nonetheless, it was suggested that public instruments could enhance developer credibility by enforcing equipment standards (e.g., LIBNOR certification), reducing smuggling, and ensuring technical qualifications through pre-qualification processes. Regarding wind energy, many investors did not show concern in terms of technical skills, mentioning that most of wind farms can be outsourced. Moreover, many skilled Lebanese might have experience in wind energy construction.
Grid integration risk	Policy derisking instruments: Strengthen EDL’s management/ operational performance; enhance bill collection efficiency and phase out energy subsidies. Financial derisking instrument: Include take-or-pay clause in the standard PPA; Financial products by development banks to assist EDL in gaining access to capital/ funding, secure grants for reconstruction.	Policy derisking instruments are effective: Interviewees, particularly equity investors, expressed strong interest in instruments aimed at de-risking grid and transmission risks. They recommended promoting the deployment of micro-grids as a transitional solution, especially within the C&I segment, with the long-term goal of interconnecting to the national grid. The full implementation of Law 318 expanded provisions for grid access, and clearer wheeling regulations were cited as critical de-risking measures. Financial derisking instruments are effective: Investors unanimously consider a take-or-pay clause a must-have and would, without its inclusion in the PPA, not endeavour an IPP project in Lebanon. As for the financial product by development banks, it was seen as limited effective specially in the current situation in Lebanon.

Counterparty risk	Policy derisking instrument: Strengthen EDL's management/ operational performance, Policy support for national grid infrastructure development including fast term release, Immediate Repairs and Infrastructure Rehabilitation; build connection substations in war targeted areas. Financial derisking instrument: Sovereign guarantees for PPA payment; Concessional public loans to IPPs. Secure grants to cover infrastructure damage cost.	Policy derisking instruments are highly effective: Several interviewees, specially equity investors, emphasized that strengthening EDL's managerial and operational capacity is both important and effective in reducing counterparty risk. However, others noted that relying solely on a sovereign guarantee would be insufficient to mitigate investor concerns. As part of public de-risking efforts, investors recommended the establishment of ESCROW or collection accounts, overseen by a credible third party, to ensure secure and transparent payment flows. Additional suggestions included contracting an international power sector consultant to enhance EDL's governance and operational performance, enforcing bill collection across all consumer categories and reinforcing financial audits and external management reviews. Financial derisking instruments are effective: Investors had doubts regarding sovereign guarantees because currently the government is in debt and there pragmatically it can not give guarantees. Same concerns regarding the Concessional public loans. However, Financial instruments such as Partial Risk Guarantees (PRGs) and the implementation of cost-reflective tariffs were considered essential components for addressing counterparty-related risks by some investors.
Financial sector risk	Policy derisking instruments: Fostering financial sector reform towards long-term green infrastructure investment; Strengthening financial sector's familiarity with renewable energy and project finance.	Policy derisking instruments are effective: To overcome capital scarcity and restore investor confidence, stakeholders recommended blended finance solutions, international guarantees (e.g., from WB, EBRD, IMF), and targeted support to rebuild the capacity of local financial institutions. Allowing ESCROW accounts abroad and forming banking consortia were also cited as practical tools to improve financing conditions.
	Financial derisking instrument: Financial products by development banks or the Central Bank, to assist project developers to gain access to capital/funding.	Regarding the capacity building in the financial sector for renewable energy project, most stakeholder agreed that many Lebanese are capable of and have the capacity to structure project financing. Financial derisking instruments are highly effective: Interviewees expressed a positive reception towards financial products from financial institutions (FIs) and emphasized the critical need for development banks to support Lebanon's energy sector and assists project developers. Moreover, some investors/ developers are engaged in a Engineering, Procurement, Construction, and Financing (EPCF) considering it a way to mitigate risk.

Political risk	Policy derisking instruments: Security guarantees for investors; Strengthen long-term policy commitment to Renewable Energy Projects, Plan for alternative funding sources. Financial derisking instrument: Risk sharing products to address political risk.	Policy derisking instruments are highly effective: The proposed instruments were seen as effective but limited by systemic governance weaknesses. Interviewees proposed multiple instruments, additional to the already existing, such as offering Political Risk Insurance (PRI) not only to international but also to local investors, issuing legal memos or decrees on a project basis, and revising laws to align with renewable energy development needs. War and terrorism-related insurance, as well as credit risk guarantees, were also recommended. Financial derisking instrument is effective: Some investors would welcome a MIGA-type[80] political risk insurance, not least due to the positive effect that the involvement of a large international development bank would have on the GoL's commitment towards the project. This involvement could also be in the form of concessional loans to GoL for the support of RE projects. However, investors also raised the concern that PRI might be prohibitively expensive for some projects, which jeopardizes its effectiveness as a derisking measure. Some investors, already pay a PRI.
Currency/ macroeconomic risk	Financial derisking instrument: Risk sharing mechanisms to address currency risk (excluding private sector instruments such as hedging, interest rate swaps); Government-backed credit lines and financial guarantees; Establish hedging mechanisms backed by international financial institutions.	Financial derisking instruments are effective: It was suggested to incorporate official exchange rate indexing and USD-denominated clauses in contracts, particularly for PPAs. Fixing pricing in hard currency was viewed as essential to attracting international capital and stabilizing payment structures. Moreover, tax incentives for RE investment and international arbitration clauses were also recommended. However, government credit lines were viewed as ineffective under current economic conditions. Headging mechanism was seen effective by many interviewees, unlike government backed credit line. The latter was said not be effective specially in this period of time with the government low on liquidity.
Climate Risk	Policy derisking instruments: Implement low climate impact technologies and streamline climate impact assessment for projects. Financial derisking instrument: Financial incentives for climate-resilient projects.	Policy and Financial derisking instruments limited effect: Most interviewees assigned a low score to climate risk instruments, stating that this risk is not significant and has minimal impact on the cost of project financing, resulting in limited need for mitigation. However, many said that an Environmental Impact Assessment (EIA).

Source: interviews with investors (equity investors/developers and debt investors). Short description of the public instruments can be looked up in Table 5.

80 MIGA = Multilateral Investment Guarantee Agency by the World Bank Group, insuring eligible projects in developing countries against losses relating to currency restrictions, expropriation, war and civil disturbance, etc.

4.2.3. Levelized Cost (Stage 3)

The modelling outputs in terms of LCOEs for wind energy, solar PV (utility and distributed) and hydro power are shown in Figure 21. The Baseline investment for the existing energy mix in Lebanon which includes installed distributed solar PV and private generators is estimated as being USD 23.8 cents per kWh for utility scale. It is also estimated to be USD 37 cents per kWh for generators alone for the distributed solar PV modelling mix baseline. The LCOE reflect the true cost of the energy mix in Lebanon with no subsidies. The cost of fuel is assumed to be an average over a period of one year.

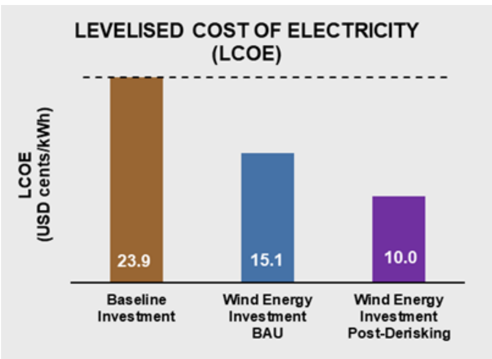
Renewable energy is shown to be less expensive than the baseline cost in both the business-as-usual and the post-derisking scenarios. Nonetheless, the public instrument package reduces the LCOE for wind energy from USD 15.1 cents per kWh (business-as-usual scenario) to USD 10 cents per kWh (post-derisking scenario), increasing the cost advantage over the baseline from USD 8.8 cents per kWh to USD 13.9 cents per kWh.

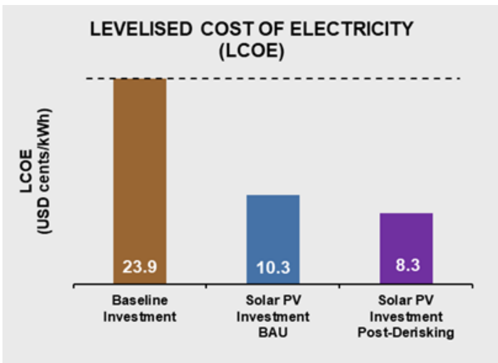
The findings are similar for solar PV, where derisking reduces the LCOE from USD 10.3 cents per kWh to USD 8.3[81] cents per kWh. The cost advantage increase for solar PV can improve its position from USD 13.6 cents per kWh to USD 15.6 cents per kWh.

A similar trend is observed for hydropower, where the application of public de-risking instruments leads to a reduction in the LCOE from USD 6.2 cents per kWh to USD 4.3 cents per kWh. This enhances hydropower's cost advantage relative to the baseline, further reinforcing its role as a competitive and reliable renewable energy source.

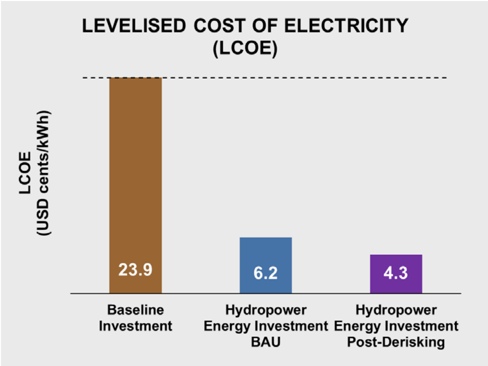
For distributed solar PV systems with storage, the de-risking measures reduce the LCOE from USD 24.7 cents/kWh to USD 17.3 cents/kWh. In comparison, for systems without storage, the LCOE decreases from USD 22.4 cents/kWh to USD 14.9 cents/kWh. This indicates that, even after de-risking, configurations without storage achieve a lower LCOE than those with storage, reflecting the additional cost burden of battery integration.

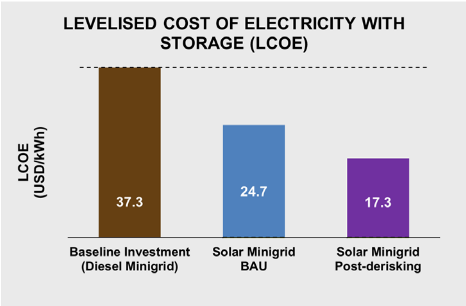
Figure 21: LCOEs for the baseline, wind energy (left), solar PV (right), hydro power (middle), mini-grid solar PV (below) investment in Lebanon.

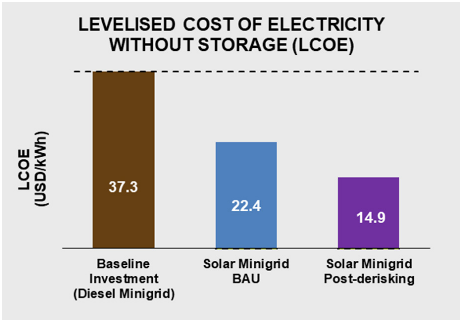




81 LCOE for utility-scale solar PV is higher than theoretical estimates and the values suggested by existing permits. This exercise incorporates the Capital Asset Pricing Model (CAPM) to account for the cost of equity, as well as the elevated risk associated with Lebanon's post-2019 economic crisis and the 2024 conflict.







Source: modelling; see Table 19 (wind), Table 20 (solar PV) and Table 21 (hydro power) as well as 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 envisioned targets for wind, solar PV and hydro power investment in Lebanon, are shown in Figure 22, Figure 23 and Figure 24. Plus, the distributed solar PV Figure 25 and Figure 26, with storage and without storage respectively.

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_2 abated). This can be a useful metric for comparing carbon prices.

Taken as a whole, the performance metrics for wind, solar PV and hydro power demonstrate how the deployment of public derisking instruments can significantly increase the competitiveness and affordability of wind energy, solar PV and hydro power in Lebanon.

For instance, the analysis shows that all three renewable energy technologies are significantly more cost-effective than the existing generation mix, with levelized costs of electricity (LCOE) post-derisking estimated at USD 10.0 cents per kWh for wind, USD 8.3 cents per kWh for solar PV, and USD 4.3 cents per kWh for hydropower, compared to USD 23.9 cents per kWh for the current baseline energy mix, taking into account the distributed solar PV generation and private generators.

Investment Leverage Ratio

For the three technologies wind energy, solar PV, and hydro the Investment Leverage Ratio shows that derisking is an efficient use of public funding. The Investment Leverage Ratio in the DREI model measures the relationship between the present value of public support (via FIT or PPA price premiums) and the total private investment mobilized in renewable energy. It is typically expressed as:

$$\text{Investment Leverage Ratio (ILR)} = \frac{\text{(Total Investment Required for RE Project)}}{\text{/(NPV of PPA Premium (FIT - Baseline Tariff)} \times \text{Energy Output)}}$$

In a standard scenario, this ratio captures the multiplier effect of policy incentives on mobilizing capital for clean energy deployment. However, in Lebanon's case (e.g., -0.5 x in the BAU scenario), solar PV is already more cost-effective than the baseline technology, meaning that the FiT or PPA tariff required for solar PV is below the baseline cost of generation. In other words, the present value of the price premium is negative, reflecting a net savings rather than a cost. This leads to a negative leverage ratio, not because the investment is negative, but because the policy support is effectively unlocking additional cost savings rather than covering a cost premium. Solar cost saving post-derisking is around USD -545 million which indicates that even with derisking instruments, solar PV is still at cost saving and much better than Lebanon baseline energy mix.

While unconventional, a negative ILR does not signal failure; instead, it highlights the economic competitiveness of solar PV in a system where the baseline is inefficient, costly, and fossil-fuel-based. It suggests that public investment is not being used to subsidize higher costs, but rather to enable access to cheaper energy. Importantly, this scenario implies that solar PV projects in Lebanon may not require tariff-based incentives to attract investment, provided that non-price barriers—such as political risk, payment delays, and regulatory uncertainty—are addressed. In fact, the negative ILR strengthens the case for policy frameworks focused on risk mitigation rather than price support.

As illustrated in the investment leverage ratio charts, Lebanon's renewable energy (RE) sector demonstrates a negative leverage ratio, improving slightly from –1.8x to –1.5x in the post-derisking scenario. This negative leverage is a positive economic signal, indicating that renewable energy is already more cost-effective than the baseline fossil fuel alternative. In other words, for every dollar of public investment, the system saves more than a dollar, highlighting the inherent cost advantage of RE technologies in Lebanon's context.

The slight shift toward zero in the post-derisking scenario reflects the added cost of implementing de-risking instruments—such as credit guarantees, technical assistance, and regulatory reforms—which are necessary to attract private capital. While these instruments introduce additional costs, they play a critical role in reducing investment risk, lowering the cost of equity and debt, and improving project bankability.

Importantly, the persistence of a negative leverage ratio—even after accounting for derisking costs—

demonstrates that renewable energy remains more affordable than conventional energy sources, and that derisking does not negate the economic advantage of RE. Instead, it enhances the investment environment, making it more attractive for private sector participation without compromising the overall cost-effectiveness of the transition.

- For wind energy, the 226 MW 2030 target is estimated to require USD 380 million in private sector investment. The modelling shows that in the business-as-usual scenario the amount spent on the price premium leverages private sector investments by a factor of – 1x. In the post-derisking scenario, a package of derisking instruments valued at USD 91.5 million will reduce the price premium payments from USD 394 million to USD 624 million over 20 years, i.e. improving the investment leverage ratio.
- For solar energy, the 330 MW 2030 target is estimated to require USD 248 million in private sector investment to meet target. In the business-as-usual scenario, with today's risk environment, achieving this target has a cost saving of USD 545 million over 20 years. As such, the investment leverage ratio is -0.5x. In the post-derisking scenario, a package of derisking instruments valued at USD 71.7 million improves investment landscape in Lebanon.
- For hydro power, the 58 MW 2030 target is estimated to require USD 114 million in private sector investment. In the business-as-usual scenario, with today's risk environment, achieving this target has a cost saving of USD 403 million over 50 years. As such, the investment leverage ratio is -0.3x. In the post-derisking scenario, adding a package of derisking instruments valued at USD 28 million improves investment landscape in Lebanon.
- For distributed solar energy with storage, the 1,200 MW 2030 target is estimated to require USD 1 billion in private sector investment to meet target. In the business-as-usual scenario, with today's risk environment, achieving this target has a cost saving of USD 937 million over 20 years. In the post-derisking scenario, a package of derisking instruments valued at USD 86 million improves investment landscape in Lebanon.
- For distributed solar energy without storage, the 1,200 MW 2030 target is estimated to require USD 513 million in private sector investment to meet target. In the business-as-usual scenario, with today's risk environment, achieving this target has a cost saving of USD 584 million over 20 years. In the post-derisking scenario, a package of derisking instruments valued at USD 43 million[82] improves investment landscape in Lebanon.

Saving Ratio

The saving ratio measures the economic efficiency of an investment by comparing the total cost savings achieved to the total costs incurred. It is calculated as the ratio of total savings to total investment costs, indicating how effectively an intervention reduces overall system costs.

This results in an incremental cost saving of USD 230 million for wind energy, USD 83 million for Solar PV

82 The solar PV generation cost for the mini-grid system without storage may appear counterintuitive at first glance. However, the model assumes that, in the absence of battery storage, energy demand during non-solar hours is met by diesel generators. Given the high operating costs of diesel, the scenario without storage results in a higher LCOE compared to the solar PV system with storage.

and USD 43 million for hydro power over the project lifetime, indicating substantial system-wide savings. The incremental cost represents the present value of the difference between the cost of electricity generated by renewable energy (typically under a FIT or PPA) and the baseline cost of electricity generation (status quo mix). A negative value, as observed for solar PV, means that renewable energy is already cheaper than fossil fuel alternatives—even without subsidies. This is particularly relevant in Lebanon, where high reliance on imported diesel and fuel oil, combined with grid inefficiencies and technical losses, makes conventional generation especially costly. With declining international solar PV costs and Lebanon's high solar irradiation, the LCOE from solar PV is now significantly below the average cost of conventional generation. In this context, the Saving Ratio multiplier reflects that the present value of savings from renewable energy—enhanced by de-risking interventions such as financial guarantees, policy reforms, and technical assistance—exceeds the cost of those interventions. Rather than indicating a loss, the saving leverage shows that each dollar spent on derisking unlocks greater economic value by reducing project costs and improving bankability. Renewable energy remains more cost-effective than the baseline, and de-risking remains essential to mobilize private capital and scale deployment.

Carbon Abatement Cost

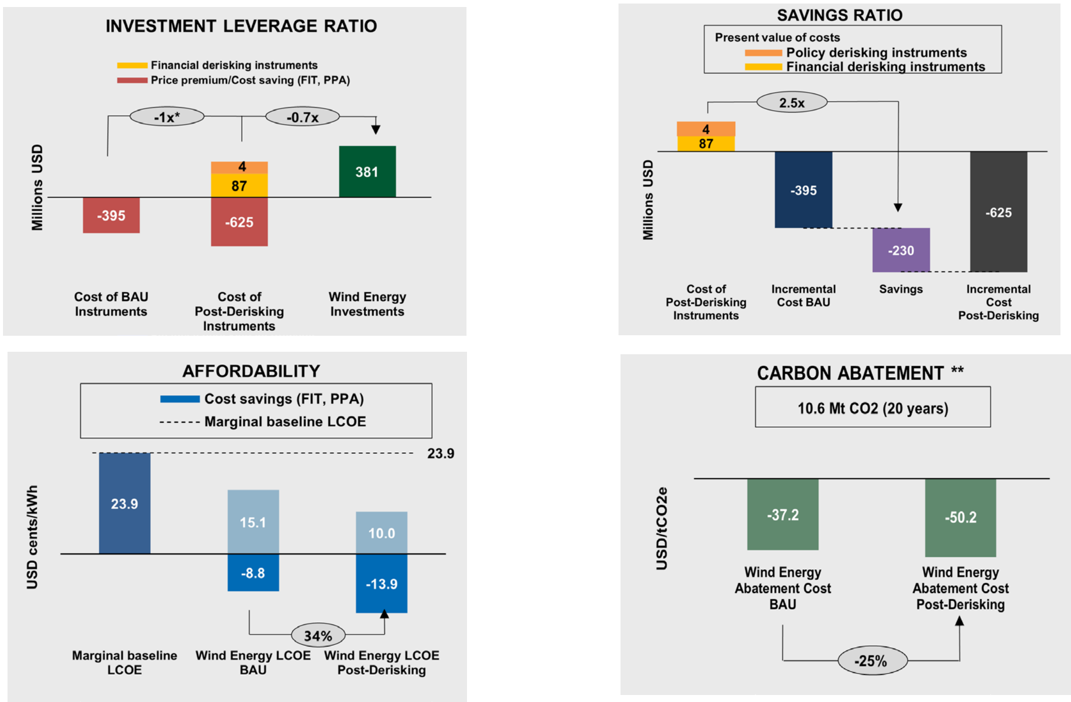
In the DREI model applied to Lebanon's context, the Carbon Abatement Cost (CAC) for utility-scale solar PV projects is calculated using the standard formula:

$$CAC = \text{Incremental Cost}/\text{Total Emissions Avoided } (tCO_2).$$

In this framework, the incremental cost represents the difference in net present value (NPV) between the renewable energy system and the conventional baseline (typically private diesel generators or thermal plants powered by heavy or light fuel oil). In Lebanon, where conventional power generation relies heavily on expensive and carbon-intensive fuel sources, the cost per MWh can exceed 180–250 USD, while solar PV systems can deliver electricity at a significantly lower LCOE, as we have seen in this exercise, around USD 10 cent per kWh pre-derisking. As a result, the incremental cost is negative, indicating that solar energy is not only cleaner but also cheaper than the baseline system. Consequently, dividing a negative cost by a positive number of tonnes of CO_2 avoided yields a negative CAC. This is a desirable outcome: it implies that carbon reductions are achieved at a net financial saving, underscoring the strong economic and environmental case for renewables in Lebanon. The negative value is a reflection of the actual economics of Lebanon's highly distorted and fuel-dependent power sector. It captures the fact that emissions can be reduced while simultaneously lowering system-level costs.

Charts of the above performance metrics are seen below in Figure 22, Figure 23, Figure 24, Figure 25 and Figure 26 for wind, solar PV, hydro power and distributed solar PV with and without storage respectively.

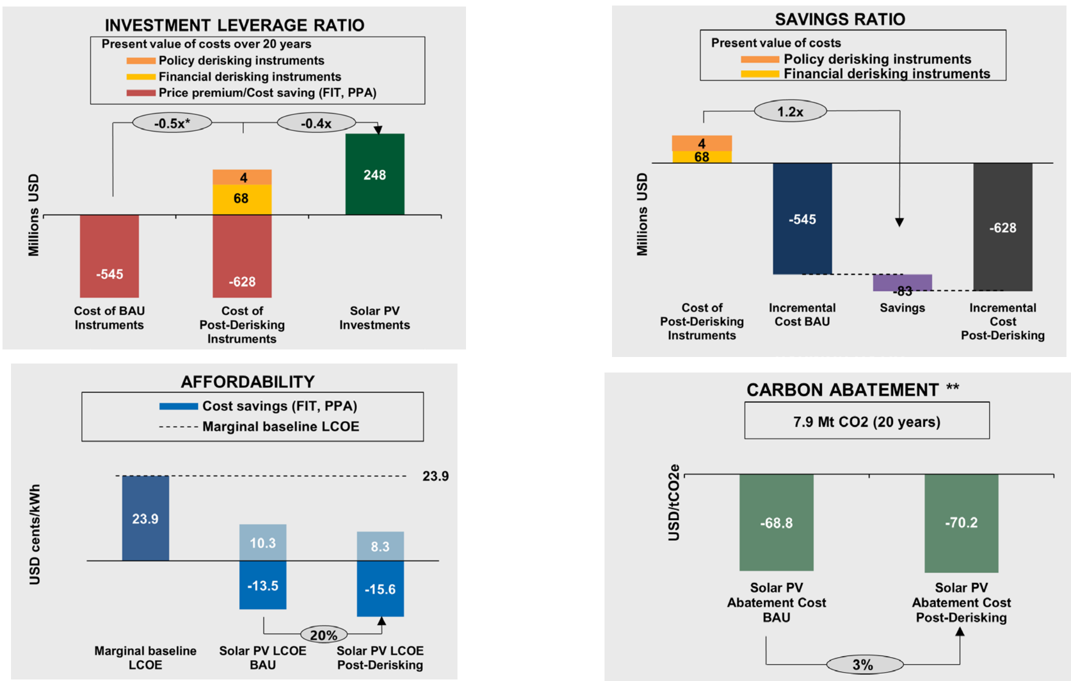
Figure 22: Performance metrics for the selected package of derisking instruments in promoting 262 MW of wind energy investment in Lebanon.



Source: modelling; see Table 30 and Annex A for details on assumptions and methodology.
**In the BAU scenario, the full 2030 investment target may not be met.*

*** The Carbon Abatement metric can be broken down into the costs of policy derisking instruments, financial derisking instruments and the cost saving. While in the BAU scenario, the total of USD -37.2 per tCO_2 is due to cost savings, in the post-derisking scenario, this breakdown for the total of USD -50.2 per tCO_2 is USD 0.41, USD 8.22 and USD -58.86, respectively.*

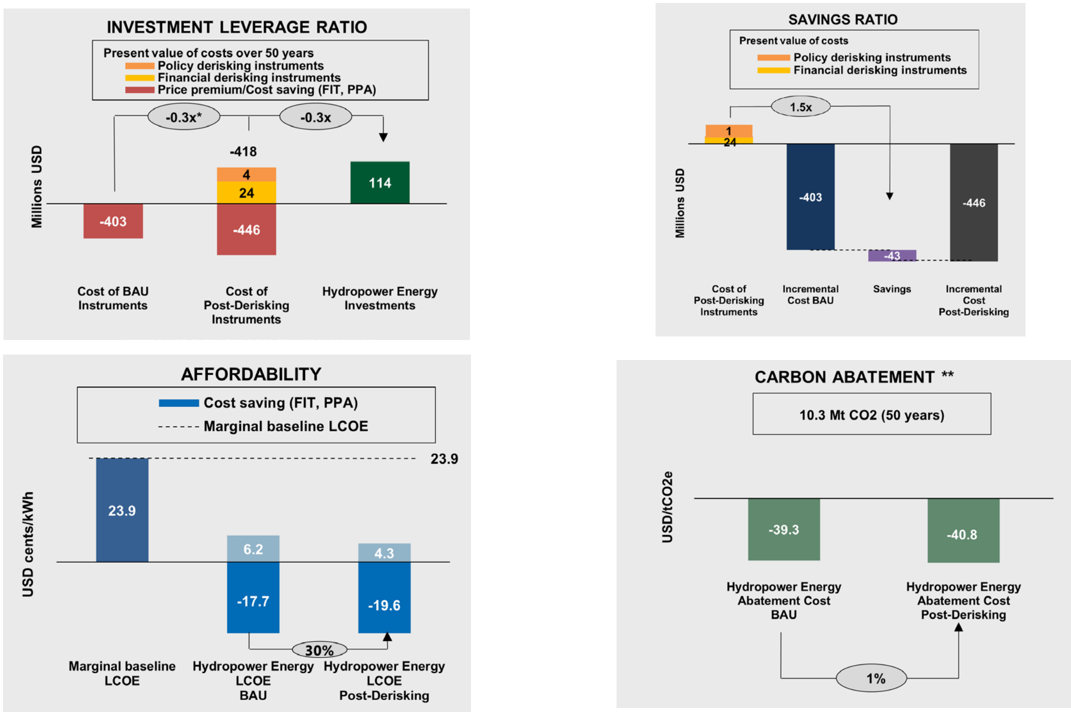
Figure 23: Performance metrics for the selected package of derisking instruments in promoting 330 MW of solar PV investment in Lebanon.



Source: modelling; see Table 31 and Annex A for details on assumptions and methodology.
**In the BAU scenario, the full 2030 investment target may not be met.*

*** The Carbon Abatement metric can be broken down into the costs of policy derisking instruments, financial derisking instruments and the cost savings. While in the BAU scenario, the total of USD -68.8 per tCO_2 is due to the cost savings, in the post-derisking scenario, this breakdown for the total of USD -70.2 per tCO_2 is USD 0.53, USD 8.54 and USD -79.25, respectively.*

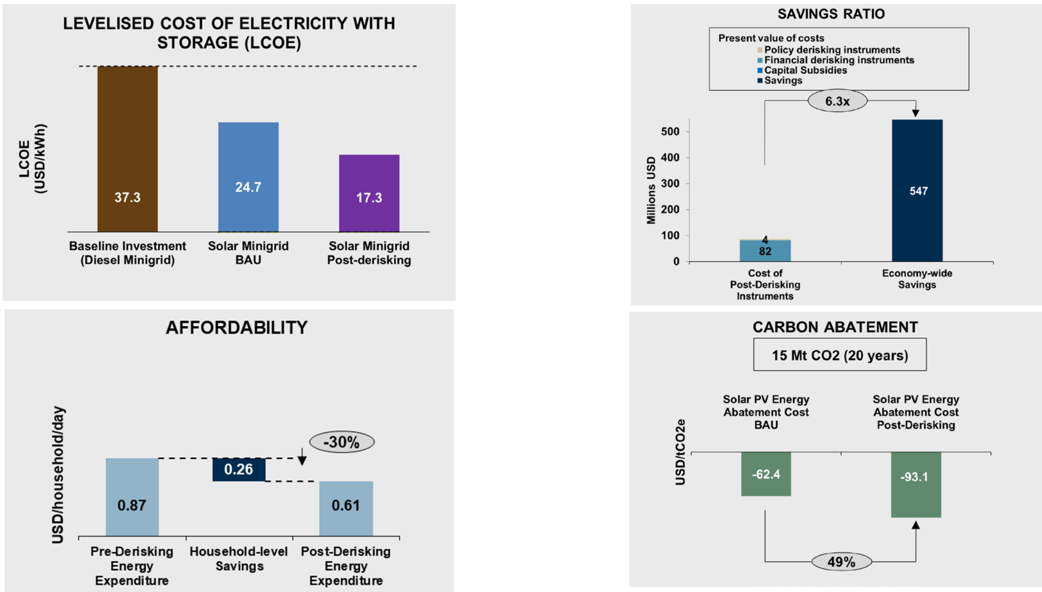
Figure 24: Performance metrics for the selected package of derisking instruments in promoting 58 MW of hydro power investment in Lebanon.



Source: modelling; see Table 32 and Annex A for details on assumptions and methodology.

**In the BAU scenario, the full 2030 investment target may not be met.*
*** The Carbon Abatement metric can be broken down into the costs of policy derisking instruments, financial derisking instruments and the price premium. While in the BAU scenario, the total of USD -39.3 per tCO_2 is due to the price premium, in the post-derisking scenario, this breakdown for the total of USD -40.8 per tCO_2 is USD 0.39, USD 2.3 and USD -43.5, respectively.*

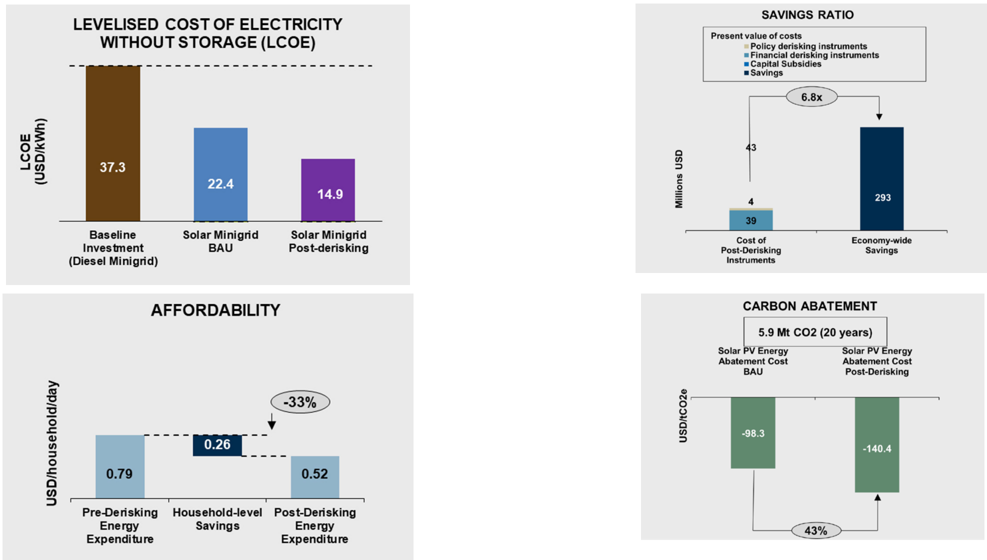
Figure 25: Performance metrics for the selected package of derisking instruments in promoting 1,200 MW of off-grid investment in Lebanon with storage.



Source: modelling; see Table 33 and Annex A for details on assumptions and methodology.
**In the BAU scenario, the full 2030 investment target may not be met.*

*** The Carbon Abatement metric can be broken down into the costs of policy derisking instruments, financial derisking instruments and the price premium. While in the BAU scenario with storage, the total of USD -62.4 per tCO_2 is due to the cost savings, in the post-derisking scenario, this breakdown for the total of USD -92.8 per tCO_2 is USD 0.56, USD 5.49 and USD -98.85, respectively.*

Figure 26: Performance metrics for the selected package of derisking instruments in promoting 1,200 MW of off-grid investment in Lebanon without storage.



Source: modelling; see Table 34 and Annex A for details on assumptions and methodology.

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

*** The Carbon Abatement metric can be broken down into the costs of policy derisking instruments, financial derisking instruments and the price premium. While in the BAU scenario without storage, the total of USD -98.3 per tCO_2 is due to the cost savings, in the post-derisking scenario, this breakdown for the total of USD -140.42 per tCO_2 is USD 0.71, USD 6.57 and USD -147.69, respectively.*

Sensitivities

A set of sensitivity analyses have been performed for wind energy, solar PV and hydro power. 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.

Three broad types of sensitivity analysis have been performed.

- Key input assumptions.
- Public instrument selection and cost-effectiveness.
- Approach to costing financial derisking instruments.

1. Sensitivity analyses varying key input assumptions.

These have been performed for the following input assumptions: (i) investment and O&M costs, (ii) capacity factor, (iii) fuel costs, and (iv) financing cost (CoE and CoD). The sensitivity analyses give an indication of the degree to which each input parameter affects the outputs. The results for this type of sensitivity are summarized in Table 9, Table 10, Table 11, Table 12 and Table 13.

For instance, an increase in the capacity factor from 31% (base case) to 35% (sensitivity analysis) reduces the post-derisking LCOE for wind energy in the base case scenario from USD 10 cents per kWh to USD 8.79 cents per kWh.

Table 9: Wind energy: summary of LCOE outputs for sensitivity analysis on key input assumptions [USD cents/kWh].

TYPE OF SENSITIVITY	DESCRIPTION OF SENSITIVITY	BASELINE LCOE	WIND BAU LCOE	WIND POST-DERISKING LCOE
Base Case	-	**23.86**	**15.11**	**10**
Wind Investment and O&M Costs	Higher investment and O&M costs; uses 2025 investment (2,000,000 USD/MW) and O&M (40,000 USD/MW/y) costs as provided by Lebanese developers. (Base case is 2025 estimate: 1,600,000 USD/MW and 32,000 USD/MW/y).	-	18.71	12.39
Wind Capacity Factor	Higher capacity factor. Sensitivity uses 35%. (Base case is 31%).	-	13.26	8.79
Fuel Costs	20% higher fuel cost projections. 20% lower fuel cost projections.	27.90 19.85	-	-
Financing Costs	1% point higher financing costs (CoE=27.0%, CoD=14%).	-	15.62	10.34
	6% lower COE, 1% lower CoD financing costs (CoE=20.0%, CoD=12%). (Base case is CoE=26.0%, CoD=13 %).	-	12.11	9.11

Source: sensitivity modelling; see Table 30 and Annex A for details of assumptions and methodology.

Table 10: Solar PV: summary of LCOE outputs for sensitivity analysis on key input assumptions [USD cents/kWh].

TYPE OF SENSITIVITY	DESCRIPTION OF SENSITIVITY	BASELINE LCOE	SOLAR PV BAU LCOE	SOLAR PV POST-DERISKING LCOE
Base Case	-	**23.86**	**10.36**	**8.28**
Solar PV Investment and O&M Costs	Higher investment and O&M costs; uses 2025 investment (850,000 USD/MW) and O&M (20,000 USD/MW/y) costs as provided by Lebanese developers. (Base case is 2025 estimate as provided by Lebanese developers: 550,000 USD/MW and 13,000 USD/MW/y).	-	12.88	10.26

Solar Capacity Factor	Higher capacity factor. Sensitivity uses 24% (Base case is 20%)	-	8.55	6.84
Fuel Costs	20% higher fuel cost projections 20% lower fuel cost projections	27.90 19.85	-	-

Source: sensitivity modelling; see Table 31 and Annex A for details of assumptions and methodology.

Table 11: Hydro power: summary of LCOE outputs for sensitivity analysis on key input assumptions [USD cents/kWh].

TYPE OF SENSITIVITY	DESCRIPTION OF SENSITIVITY	BASELINE LCOE	HYDRO BAU LCOE	HYDRO POST-DERISKING LCOE
Base Case	-	**23.88**	**6.19**	**4.30**
Hydro Investment and O&M Costs	Higher investment and O&M costs; uses 2025 investment (2,000,000 USD/MW) and O&M (22,000 USD/MW/y) costs as provided by Lebanese developers. (Base case is 2025 estimate: 1,800,000 USD/MW and 18,000 USD/MW/y).	-	6.86	4.79
Hydro Capacity Factor	Higher capacity factor. Sensitivity uses 60% (Base case is 58%)	-	6.0	4.2
Fuel Costs	20% higher fuel cost projections 20% lower fuel cost projections	27.90 19.85	-	-
Financing Costs	1% point higher financing costs (CoE=27.0%, CoD=14%)		6.58	4.51
	(Basecase is CoE=26.0%, CoD=13%)			

Source: sensitivity modelling; see Table 32 and Annex A for details of assumptions and methodology.

Table 12: Solar PV with storage: summary of LCOE outputs for sensitivity analysis on key input assumptions [USD cents/kWh].

TYPE OF SENSITIVITY	DESCRIPTION OF SENSITIVITY	BASELINE LCOE	SOLAR BAU LCOE	SOLAR POST-DERISKING LCOE
Base Case	-	**37.3**	**24.7**	**17.3**
Investment and O&M Costs	Higher investment and O&M costs: 15%	-	28.4	20
Financing Costs	1% point higher financing costs: CoE=27%, CoD=14% 1% point lower financing costs: CoE=25%, CoD=12% vs. Base case CoE=26%, CoD=13%	-	25.5 23.9	17.9 16.8
Capital Structure	Higher/Lower Debt share in capital structure 20% Equity 80% debt vs. Base case is 50/50%	-	24.7	16.5

Source: sensitivity modelling; see Table 33 and Annex A for details of assumptions and methodology.

Table 13: Solar PV without storage: summary of LCOE outputs for sensitivity analysis on key input assumptions [USD cents/kWh].

TYPE OF SENSITIVITY	DESCRIPTION OF SENSITIVITY	BASELINE LCOE	SOLAR BAU LCOE	SOLAR POST-DERISKING LCOE
Base Case	-	**37.3**	**22.4**	**14.9**
Investment and O&M Costs	Higher investment and O&M costs: 15%	-	25.0	16.7
Financing Costs	1% point higher financing costs: CoE=27%, CoD=14% 1% point lower financing costs: CoE=25%, CoD=12% vs. Base case CoE=26%, CoD=13%	-	23.2 21.6	15.5 14.4
Capital Structure	Higher/Lower Debt share in capital structure 20% Equity 80% debt vs. Base case is 50/50%	-	22.4	13.9

Source: sensitivity modelling; see Table 33 and Annex A for details of assumptions and methodology.

2. Sensitivity analysis on public instrument selection and cost-effectiveness.

Two types of sensitivities have been performed on public derisking instruments: on selecting different sub-sets of instruments, and on the cost-effectiveness of individual instruments. Detailed descriptions for each instrument are found in Table 5. For these sensitivity analyses, the key relationship to analyse is between the cost of the instruments versus their impact on lowering generation costs, and hence the economic savings they create.

The following findings become evident from these sensitivities. First, the sensitivities show that implementing public derisking measures are always cost effective, across all the scenarios. In other words, investment in the cost of derisking instruments is always more than paid back in terms of lower generation costs and economic savings. Second-with an important caveat, below- the findings show a range of cost-effectiveness across instruments, including policy derisking instruments being generally more cost-effective than financial derisking instruments. As an example, for wind energy, policy derisking instruments cost USD 4 million saving the economy USD 99 million. Whereas financial derisking instruments cost USD 87 million, saving the economy USD 207 million.

An important caveat is that the modelling cannot indicate whether a particular instrument is necessary; for example, while less cost-effective, financial derisking instruments such as public loans may be necessary at this stage of Lebanon's market development; likewise, power market risk activities, which encompass issues such as legislation and bidding processes, while less cost-effective than other policy derisking measures, may similarly be necessary. Therefore, selecting and eliminating particular instruments based on cost-effectiveness alone may come with risks, and may reduce the chances of meeting Lebanon's full 2030 investment targets.

(i) Sub-sets of instruments

While the base case scenario considers the complete set of instruments listed in Table 5, this type of sensitivity analysis examines the impact and cost effectiveness of different sub-sets of public instruments: (i) only policy derisking instruments, (ii) only financial derisking instruments, and (iii) only instruments targeting those risk categories with the highest impact on financing cost. The key results for this type of sensitivity are summarized in Table 14, Table 15 and Table 16[83] below, and shown graphically in Figures 30-32 in Annex B.

Table 14: Wind energy: summary of key outputs for sensitivity analysis on sub-sets of derisking instruments.

Scenario	Description Of Sensitivity	Post-Derisking Cost Of Financing		Cost Of Instruments (USD Million)	SAVINGS TO THE ECONOMY (USD million)
		Equity	Debt		
Base Case	Base case instruments.	19.8%	9.1%	Policy: 4 Financial: 88 Total: 92	230.0
Policy derisking only	Policy derisking instruments only	23.6%	12.0%	Policy: 4 Financial: -	99
Financial derisking only	Financial derisking instruments only	22.2%	10.1%	Policy: - Financial: 91	207
High impact risk case	Policy & financial derisking instruments addressing only high impact risk categories	21.9%	10.3%	Policy: 1 Financial: 63 Total: 65	205

83 Sensitivity analysis of public instruments was conducted only for utility-scale projects, as the current off-grid electrification UNDP model does not include this functionality for distributed energy systems.

Table 15: Solar PV: summary of key outputs for sensitivity analysis on sub-sets of derisking instruments.

Scenario	Description Of Sensitivity	Post-Derisking Cost Of Financing		Cost Of Instruments (USD Million)	SAVINGS TO THE ECONOMY (USD million)
		Equity	Debt		
Base Case	Base case instruments.	19.8%	9.1%	Policy: 4 Financial: 68 Total: 72	83.0
Policy derisking only	Policy derisking instruments only	23.6%	12.0%	Policy: 4 Financial: -	18.0
Financial derisking only	Financial derisking instruments only	22.2%	10.1%	Policy: - Financial: 72	59.0
High impact risk case	Policy & financial derisking instruments addressing only high impact risk categories	22.0%	10.1%	Policy: 1 Financial: 46 Total: 47	62.0

Table 16: Hydro Power: summary of key outputs for sensitivity analysis on sub-sets of derisking instruments.

Scenario	Description Of Sensitivity	Post-Derisking Cost Of Financing		Cost Of Instruments (USD Million)	SAVINGS TO THE ECONOMY (USD million)
		Equity	Debt		
Base Case	Base case instruments.	19.8%	8.9%	Policy: 4 Financial: 24 Total: 28	43
Policy derisking only	Policy derisking instruments only.	23.5%	11.8%	Policy: 4 Financial: -	11
Financial derisking only	Financial derisking instruments only.	22.3%	10.1%	Policy: - Financial: 25	36
High impact risk case	Policy & financial derisking instruments addressing only high impact risk categories.	22.7%	11.3%	Policy: 1 Financial: 24 Total: 26	15

(ii) Cost effectiveness of individual instruments

This type of sensitivity analysis examines the cost effectiveness of individual instruments, in both the policy derisking instrument and financial derisking instrument categories. In order to have comparability between instruments, the metric used to analyse this sensitivity is the USD cost of each instrument to lower the LCOE by USD 0.10 cents/kWh[84]. The lower this metric, the more cost-effective the instrument is.

84 This metric is sensitive to the particular investment target (e.g. 300 MW or 450 MW); therefore it can be misleading, particularly for instruments with variable cost components, to compare this metric across investment targets or technologies.

Table 17 below sets out the results of the sensitivities on individual instrument cost effectiveness.

Table 17: Wind, solar PV and hydro: summary of results for sensitivity analysis on the cost-effectiveness of individual instruments.

RISK CATEGORY	INSTRUMENT	WIND (226 MW) USD cost of instrument/ USD 0.10 cents of impact on post-derisking LCOE	SOLAR (330 MW) USD cost of instrument/ USD 0.10 cents of impact on post-derisking LCOE	HYDRO (58 MW) USD cost of instrument/ USD 0.10 cents of impact on post-derisking LCOE
Policy Derisking Instruments				
Power Market Risk	Various	$634,000	$894,000	$1,184,000
Permits Risk	Various	$139,000	$218,000	$503,000
Social Acceptance Risk	Various	$1,087,000	$1,589,000	$3,240,000
Developer Risk	Various	$1,190,000	$1,116,000	$1,357,000
Grid/Transmission Risk	Various	$265,000	$375,000	$312,000
Counterparty Risk	Various	$42,000	$59,000	$106,000
Financial sector Risk	Various	$72,000	$96,000	$177,000
Political Risk	Various	$154,000	$191,000	$308,000
Climate Risk	Various	NA	NA	$1,013,000
Financial Derisking Instruments				
Grid/Transmission Risk	Take or Pay Clause in PPA	$271,000	$277,000	$134,000
Counterparty Risk	Government Guarantee for PPA	$4,780,000	$5,889,000	$3,418,000
Financial sector Risk and Currency Risk	Financial products by development banks or the Central Bank Public Loans	$8,000	$11,000	$43,000
Political Risk	Political Risk Insurance for Equity Investment	$300,000	$300,000	$111,000
Climate Risk	Financial incentives for climate-resilient projects	NA	NA	$3,874,000
Currency Risk	Fully Indexing to dollar	$25,392,000	$29,486,000	$20,330,000

3. Sensitivity analyses on approach to costing financial derisking instruments

The costing of financial derisking instruments is complex, where different approaches can be taken, each with their pros and cons. For example, a conservative costing methodology may cost public loans at their face value or, less conservatively, to cost loans taking a loss reserve approach. A more aggressive costing methodology may assign zero cost to public loans, reasonably assuming that the loans should be paid back in full, and that providers of public loans will price in any default risk and cost of capital in the loan's terms and fees.

This sensitivity analysis examines these alternative costing approaches, analysing a high-cost scenario and a low-cost scenario. The assumptions behind these approaches are provided in Annex A. The key cost figures resulting from the different costing approaches are summarized in Table 18, Table 19 and Table 20[85] below, and shown graphically in Figure 33, Figure 34 and Figure 35 in Annex B.

Table 18: Wind energy: summary of public cost outputs for sensitivity analysis varying costing approach for financial derisking instruments.

Scenario	Description Of Scenario	Cost To Public (USD Million)				Savings Ratio	Carbon Abatement Cost (USD/tCO$_2$)
		Actual/ Opp cost	Loss reserves	Face Value	Total		
Base case	Actual and opportunity cost for take or pay and full indexing, and opportunity cost for government guarantee; loss reserves for public loans and PRI.	72.3	15.0	27.7	114.5	2.5x	-$50.2
High cost approach	Actual and opportunity cost for take or pay and full indexing; loss reserve for PRI; face value for government guarantee and public loans.	46.3	2.0	213.7	262.0	0.9x	-$33.8
Low cost approach	Actual and opportunity cost for take or pay and full indexing, loss reserve for PRI; no cost for government guarantee and public loans.	46.3 (through take-or-pay clause and full indexing)	2.0	0.0	48.2	4.4	-$53.9

85 This exact sensitivity is not included in the off-grid electrification (DREI 2018) model. However, a graphic representation is included in ANNEX B and done as a manual sensitivity check.

Table 19: Solar PV: summary of public cost outputs for sensitivity analysis varying costing approach for financial derisking instruments.

Scenario	Description Of Scenario	Cost To Public (USD Million)				Savings Ratio	Carbon Abatement Cost (USD/tCO_2)
		Actual/ Opp cost	Loss reserves	Face Value	Total		
Base case	Actual and opportunity cost for take or pay and full indexing, and opportunity cost for government guarantee; loss reserves for public loans and PRI.	58.3	9.3	31.5	99.1	1.2x	-$70.2
High cost approach	Actual and opportunity cost for take or pay and full indexing; loss reserve for PRI; face value for government guarantee and public loans.	34.2	1.9	134.1	170.2	0.5x	-$57.2
Low cost approach	Actual and opportunity cost for take or pay and full indexing, loss reserve for PRI; no cost for government guarantee and public loans.	34.2 (through take-or-pay clause)	1.9	0.0	36.2	2.1x	-$74.16

Table 20: Hydro Power: summary of public cost outputs for sensitivity analysis varying costing approach for financial derisking instruments.

Scenario	Description Of Scenario	Cost To Public (USD Million)				Savings Ratio	Carbon Abatement Cost (USD/tCO_2)
		Actual/Opp cost	Loss reserves	Face Value	Total		
Base case	Actual and opportunity cost for take or pay and full indexing, and opportunity cost for government guarantee; loss reserves for public loans and PRI.	17.1	4.7	11.5	33.3	1.7x	-$40.98
High cost approach	Actual and opportunity cost for take or pay and full indexing; loss reserve for PRI; face value for government guarantee and public loans.	10.1	0.3	64.1	74.5	0.5x	-$35.9
Low cost approach	Actual and opportunity cost for take or pay and full indexing, loss reserve for PRI; no cost for government guarantee and public loans.	10.1 (through take-or-pay clause and full indexing)	0.3	0.0	10.4	3.0x	-$42.1

4.2.5 Summary Data Tables

Table 21: Summary modelling assumptions for wind energy in Lebanon.

WIND TARGET AND RESOURCES	
2030 Target (in MW)	226
Capacity Factor (%)	31.1%
Total Annual Energy Production for Target (in MWh)	614,720
BASELINE ENERGY MIX	
CCGT on light fuel	35%
OCGT on light fuel	1%
Hydro	4%
Heavy fuel	25%
Solar PV distributed	9%
Genset	26%
Grid Emission Factor (tCO2e/MWh)	0.691
GENERAL COUNTRY INPUTS	
Effective Corporate Tax Rate (%)	17%
Public Cost of Capital (%)	13%

	Business-as-Usual Scenario	Post Derisking Scenario
FINANCING COSTS		
Capital Structure		
Debt/Equity Split	30 %/ 70%	80 %/ 20%
Cost of Debt		
Concessional public loan	NA	5.0%
Commercial loans with public guarantees	NA	NA
Commercial loans without public guarantees	13.0%	9.1%
Loan Tenor		
Concessional public loan	NA	20 years
Commercial loans with public guarantees	NA	NA
Commercial loans without public guarantees	0 years	13 years
Cost of Equity	26.0%	19.8%
Weighted Average Cost of Capital (WACC) (After-tax)	21.4%	8.6%
INVESTMENT		
Total Investment (USD million)	$380.7	$380.7
Debt (USD million)		
Concessional public loan	$0.0	$152.3
Commercial loans with public guarantees	$0.0	$0.0
Commercial loans without public guarantees	$114.2	$152.3
Equity (USD million)	$266.5	$76.1
Private Sector Equity	NA	NA
Public Sector Equity	NA	NA
COST OF PUBLIC INSTRUMENTS		
Policy Derisking Instruments (USD million, present value)		
Power Market Risk Instruments	NA	$1.9
Permits Risk Instruments	NA	$0.4
Social Acceptance Risk Instruments	NA	$0.6
Developer Risk Instruments	NA	$0.5
Grid/Transmission Risk Instruments	NA	$0.4
Counterparty Risk Instruments	NA	$0.1
Financial sector Risk Instruments	NA	$0.1
Political Risk Instruments	NA	$0.3
Currency Risk Instruments	NA	NA
Total	NA	$4.4
Financial Derisking Instruments (USD million, present value)		
Financial sector Risk Instruments	NA	$1.2
Counterparty Risk Instruments	NA	$26.0
Currency Risk Instruments	NA	NA
Public Loans	NA	$13.1
Public Guarantees for Commercial Loans	NA	NA
Political Risk Instruments	NA	$2.0
Currency Risk Instruments	NA	$45.0
Total	NA	$87.3
Direct Financial Incentives (USD million)		
Present Value of 20 year PPA Premium	($394.6)	($624.9)

Source: modelling; see Annex A for details of assumptions and methodology. Financing costs are average costs from 2025-2030.

Table 22: Summary modelling assumptions for solar PV in Lebanon.

SOLAR PV TARGET AND RESOURCES	
2030 Target (in MW)	330
Capacity Factor (%)	19.8%
Total Annual Energy Production for Target (in MWh)	573,210
BASELINE ENERGY MIX	
CCGT on light fuel	35%
OCGT on light fuel	1%
Hydro	4%
Heavy fuel	25%
Solar PV distributed	9%
Genset	26%
Grid Emission Factor (tCO2e/MWh)	0.691
GENERAL COUNTRY INPUTS	
Effective Corporate Tax Rate (%)	17%
Public Cost of Capital (%)	13%

	Business-as-Usual Scenario	Post Derisking Scenario
FINANCING COSTS		
Capital Structure		
Debt/Equity Split	30 %/ 70%	70 %/ 30%
Cost of Debt		
Concessional public loan	NA	5.0%
Commercial loans with public guarantees	NA	NA
Commercial loans without public guarantees	13.0%	9.1%
Loan Tenor		
Concessional public loan	NA	10 years
Commercial loans with public guarantees	NA	10
Commercial loans without public guarantees	0 years	10 years
Cost of Equity	26.0%	19.8%
Weighted Average Cost of Capital (WACC) (After-tax)	21.4%	10.0%
INVESTMENT		
Total Investment (USD million)	$247.5	$247.5
Debt (USD million)		
Concessional public loan	$0.0	$86.6
Commercial loans with public guarantees	$0.0	$0.0
Commercial loans without public guarantees	$74.3	$86.6
Equity (USD million)	$173.3	$74.3
Private Sector Equity	NA	NA
Public Sector Equity	NA	NA
COST OF PUBLIC INSTRUMENTS		
Policy Derisking Instruments (USD million, present value)		
Power Market Risk Instruments	NA	$1.9
Permits Risk Instruments	NA	$0.4
Social Acceptance Risk Instruments	NA	$0.5
Developer Risk Instruments	NA	$0.4
Grid/Transmission Risk Instruments	NA	$0.4
Counterparty Risk Instruments	NA	$0.1
Financial sector Risk Instruments	NA	$0.1
Political Risk Instruments	NA	$0.3
Currency Risk Instruments	NA	NA
Total	NA	$4.2
Financial Derisking Instruments (USD million, present value)		
Grid/Transmission Risk Instruments	NA	$0.9
Counterparty Risk Instruments	NA	$24.0
Financial sector Risk Instruments	NA	NA
Public Loans	NA	$7.4
Public Guarantees for Commercial Loans	NA	NA
Political Risk Instruments	NA	$1.9
Currency Risk Instruments	NA	$33.3
Total	NA	$67.6
Direct Financial Incentives (USD million)		
Present Value of 20 year PPA Premium	($544.5)	($627.6)

Source: modelling; see Annex A for details of assumptions and methodology. Financing costs are average costs from 2025-2030.

Table 23: Summary modelling assumptions for hydro power in Lebanon.

HYDRO TARGET AND RESOURCES	
2030 Target (in MW)	58
Capacity Factor (%)	58.4%
Total Annual Energy Production for Target (in MWh)	296,902
BASELINE ENERGY MIX	
CCGT on light fuel	35%
OCGT on light fuel	1%
Hydro	4%
Heavy fuel	25%
Solar PV distributed	9%
Genset	26%
Grid Emission Factor (tCO2e/MWh)	0.691
GENERAL COUNTRY INPUTS	
Effective Corporate Tax Rate (%)	17%
Public Cost of Capital (%)	13%

	Business-as-Usual Scenario	Post Derisking Scenario
FINANCING COSTS		
Capital Structure		
Debt/Equity Split	90 %/ 10%	90 %/ 10%
Cost of Debt		
Concessional public loan	NA	5.0%
Commercial loans with public guarantees	NA	NA
Commercial loans without public guarantees	13.0%	8.9%
Loan Tenor		
Concessional public loan	NA	25 years
Commercial loans with public guarantees	NA	25
Commercial loans without public guarantees	50 years	50 years
Cost of Equity	26.0%	19.8%
Weighted Average Cost of Capital (WACC) (After-tax)	12.3%	7.2%
INVESTMENT		
Total Investment (USD million)	$114.1	$114.1
Debt (USD million)		
Concessional public loan	$0.0	$51.3
Commercial loans with public guarantees	$0.0	$0.0
Commercial loans without public guarantees	$102.7	$51.3
Equity (USD million)	$11.4	$11.4
Private Sector Equity	NA	NA
Public Sector Equity	NA	NA
COST OF PUBLIC INSTRUMENTS		
Policy Derisking Instruments (USD million, present value)		
Power Market Risk Instruments	NA	$1.5
Permits Risk Instruments	NA	$0.4
Social Acceptance Risk Instruments	NA	$0.4
Developer Risk Instruments	NA	$0.5
Grid/Transmission Risk Instruments	NA	$0.4
Counterparty Risk Instruments	NA	$0.1
Financial sector Risk Instruments	NA	$0.1
Political Risk Instruments	NA	$0.3
Climate Risk Instruments	NA	$0.2
Total	NA	$4.0
Financial Derisking Instruments (USD million, present value)		
Financial sector Risk Instruments	NA	$0.3
Counterparty Risk Instruments	NA	$7.1
Financial sector Risk Instruments	NA	NA
Public Loans	NA	$4.4
Public Guarantees for Commercial Loans	NA	NA
Political risk insurance	NA	$0.3
Climate Risk Instruments	NA	$2.1
Currency Risk Instruments	NA	$9.8
Total	NA	$23.9
Direct Financial Incentives (USD million)		
Present Value of 20 year PPA Premium	($403.1)	($446.0)

Source: modelling; see Annex A for details of assumptions and methodology. Financing costs are average costs from 2025-2030.

Table 24: Summary modelling assumptions for distributed solar PV with storage.

SOLAR PV-BATTERY TECHNOLOGY	
2030 Electrification Target (number of household connections)	600,000
Average Capacity Factor (%)	13.4%
Average System Size	
Solar PV (kW)	100
Battery (kWh)	200
Total Annual Serviced Demand (kWh)	1,407,253,347
Total System Size to Reach 2030 Target (kW)	1,200,000
BASELINE	
Baseline energy mix	
Diesel generator	100%
Average system size (kW)	32
Diesel Emission Factor (tCO2e/MWh)	0.534
GENERAL COUNTRY INPUTS	
Effective Corporate Tax Rate (%)	17%
Public Cost of Capital (%)	13%

Source: modelling; see Annex A for details of assumptions and methodology. Financing costs are average costs from 2025-2030.

Table 25: Summary modelling assumptions for distributed solar PV without storage.

SOLAR PV-BATTERY TECHNOLOGY	
2030 Electrification Target (number of household connections)	600,000
Average Capacity Factor (%)	7.1%
Average System Size	
Solar PV (kW)	100
Battery (kWh)	0
Total Annual Serviced Demand (kWh)	742,287,507
Total System Size to Reach 2030 Target (kW)	1,200,000
BASELINE	
Baseline energy mix	
Diesel generator	100%
Average system size (kW)	32
Diesel Emission Factor (tCO2e/MWh)	0.53
GENERAL COUNTRY INPUTS	
Effective Corporate Tax Rate (%)	17%
Public Cost of Capital (%)	13%

Source: modelling; see Annex A for details of assumptions and methodology. Financing costs are average costs from 2025-2030.

5. CONCLUSIONS

5. CONCLUSIONS

The results in this report should not be interpreted as a definitive quantitative analysis of wind energy and solar PV in Lebanon 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 Lebanon

The results confirm that financing costs for wind energy, solar PV and hydropower in Lebanon are currently high, particularly in comparison to countries with more favourable investment environments. The cost of equity today is estimated as being 26.0%, and the cost of debt as 13%[86]. The modelling starts from ten different risk categories and evaluates to what extent they contribute to higher financing costs in Lebanon for utility and distributed renewable energy. When comparing to Germany, counter party risk, financial sector risk, political risk, permit risk, and currency risk are identified as being the most significant risk categories contributing together an estimated 12.3% to the higher cost of equity and 6.6% to the higher cost of debt. However, when compared to Jordan, permit risk, grid and transmission risk, counterparty risk, financial sector risk and currency risk are identified as being the most significant risk categories, contributing together an estimated 7.9% to the higher cost of equity and 3.9% to the higher cost of debt (excluding permit risk). This also holds correct for utility scale and distributed renewable energy.

- 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 as envisioned in Lebanon's National Renewable Energy Action Plan. The derisking measures bring down the generation cost of wind energy from USD 15.1 cents per kWh to USD 10.0 cents per kWh, solar PV energy from USD 10.3 cents per kWh to USD 8.3 cents per kWh and hydro power run-of-river from USD 6.2 cents per kWh to USD 4.3 cents per kWh. As for the distributed solar PV, the cost goes down from USD 24.7 cents per kWh to USD 17 cents per kWh with storage and USD 22.4 cents per kWh to USD 15 cents per kWh without storage. These lower generation costs have important implications for the affordability for Lebanese 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, solar PV and hydro power.
- For wind energy, in the business as usual scenario, the modelling estimates cost savings totaling USD 394 million that can be achieved over the next 20 years. However, if a total of USD 92 million is invested in derisking measures during the same period (USD 18 million per year until 2030[87]), achieving the target permits[88], wind energy costs will decrease by 33.8%, resulting in additional savings of USD 230 million, thereby this approach would lead to total generation cost savings of USD 624 million over the next 20 years.

86 USD denominated cost of equity and cost of debt.

87 Annual costs are given in 2024 USD.

88 For wind energy 226 MW, for Solar PV 330 MW, for hydro power 58 MW and 1,200 MW for distributed solar PV.

- For solar PV, in the business-as-usual scenario, the modelling estimates cost saving of USD 545 million over the investment's lifespan of 20 years. However, if a total investment of USD 71 million in derisking measures (USD 14.2 million per year until 2030) is made achieving the target permits, solar PV cost will also become 20% cheaper and the cost saving are reduced even more to USD 628 million, saving additional USD 83 million in generation costs over the next 20 years.
- For hydro power, in the business-as-usual scenario, the modelling estimates cost saving of USD 403 million over the investment's lifespan of 50 years. However, if a total of USD 28 million is invested in derisking measures (USD 5.6 million per year until 2030), achieving the target permits, hydro power cost will decrease by 30.4%, resulting in savings of USD 446 million, saving additional USD 43 million in generation costs over the next 50 years.
- For distributed solar PV with storage, in the business-as-usual scenario, the modelling estimates that there is an economy-wide savings when investing in solar mini-grid totaling USD 937 million over the lifespan of the investment of 20 years. However, if a total investment of USD 86 million is made in derisking measures (USD 17 million per year until 2030) distributed solar PV power will also become 32% cheaper and the cost saving are reduced even more to USD 1.5 billion, saving USD 543 million in generation costs over the next 20 years due to derisking.
- For distributed solar PV without storage, in the business-as-usual scenario, the modelling estimates that there is a cost saving when investing in solar mini-grid totaling USD 584 million over the lifespan of the investment of 20 years. However, if a total investment of USD 45 million is made in derisking measures (USD 9 million per year until 2030) achieving the target permits given, distributed solar PV power will also become 33% cheaper and the cost saving are reduced even more to USD 877 million, saving USD 293 million in generation costs over the next 20 years.

While the financial impact of renewable energy is significant for society, particularly in reducing electricity bills and ensuring access to sustainable energy, the primary focus of this study is on the investment landscape. The analysis highlights how policy and financial instruments play a critical role in enabling private sector investment and reducing the risks associated with renewable energy development in Lebanon.

Overall, the findings suggest that implementing derisking instruments immediately should be prioritized wherever possible. This approach will help mitigate residual risks and encourage investors to finance renewable energy projects in Lebanon.

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 (2013) ("DREI report (2013)" and "DREI report (2018)")[89]. This annex is organized 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 Levelized 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 2025 US dollars and covers a core period from January 1, 2025 (approximating the present time) to December 31, 2030 (the horizon for Lebanon's envisioned RE targets). Generation technologies may have asset lifetimes which extend beyond 2030, and this is captured by the financial tool.

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

A.1 Risk Environment (Stage 1)

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

- 19 structured interviews with investors in wind energy, solar PV and hydro power in Lebanon - 12 with equity investors or developers, 7 with debt investors.
- 2 structured interviews with RE investors in the best-in-class and best-in-region countries, held by KPMG's DREI work team, one from Germany and one from Jordan.
- Multiple informational interviews with and inquiries to the interviewees and other public and RE actors.
- UNDP's and KPMG's experience with, and analysis of large-scale renewable energy and the electricity sector in Lebanon.

In order to gather these data, KPMG project team made a field mission to Lebanon at the end of March 2025. Three structured interviews as well as a number of inquiries were conducted remotely.

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 DREI report (2013; Section 2.1.1). It is composed of 10 risk categories and 21 underlying barriers. These risk categories, barriers and their definitions can be found in Table 5 in the body of this report.

89 Same methodology is used for utility scale and distributed solar PV

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, solar PV and hydro power 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 1 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. The typical interview took between 60 and 100 minutes.

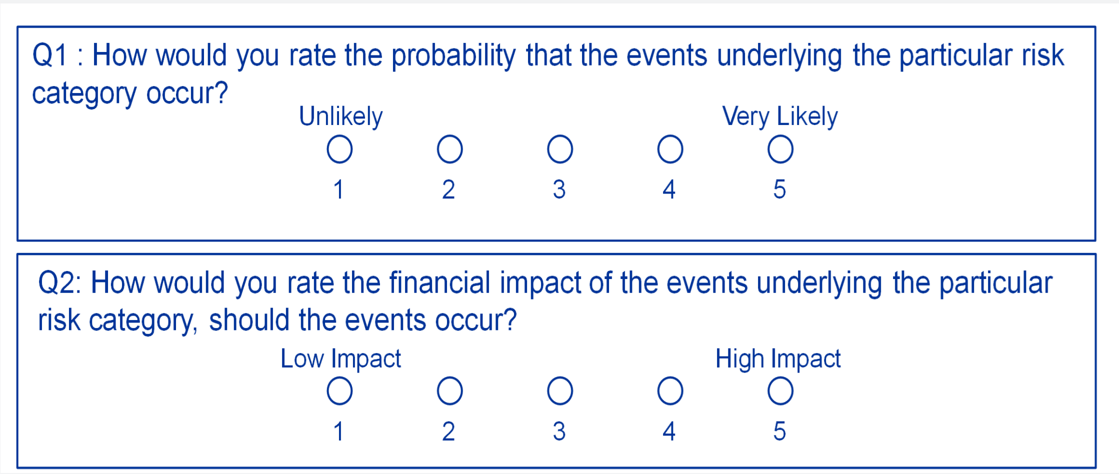
Box 1: Methodology for quantifying the impact of risk categories on higher financing costs.

1. Interviews

Interviews were held with debt and equity investors active in wind energy, solar PV and hydro power in Lebanon, as well as in the selected best-in-class countries, Germany and Jordan. 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 24.
- 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 27: Interview questions to quantify the impact of risk categories on the cost of equity and debt.



2. Processing the data gathered

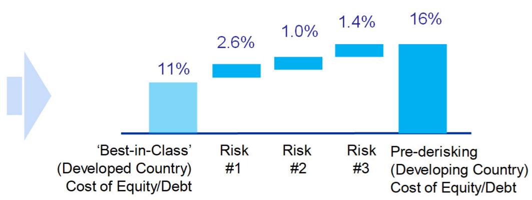
The data gathered from interviews are then processed. The methodology involves identifying the total difference in the cost of equity or debt between the developing country (Lebanon) and the best-in-class developed countries (Germany and Jordan). This figure for the total difference reflects the total 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 occurring above the probability of such an event occurring in a best-in-class countries and the financial impact of the event if such an event occurs (see DREI Report (2013; 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 prorate and apportion the total difference in the cost of equity or debt.

A very simplified example, demonstrating the basic approach, is demonstrated in Figure 28.

Figure 28: Illustrative simplified application of the methodology to determine the impact of risk categories on increasing financing costs.

Cost of equity					
Developing County	16%				
Best-in-class Developed Country	11%				
Total Difference	5%				
Average 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					
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%
					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, solar PV and hydro power investment, as set out in Boxes 2, 3 and 4 respectively. To maintain consistency, these assumptions were subsequently used to shape the inputs in the LCOE calculation for wind energy in Stage 3.

Box 2: The eight investment assumptions for wind energy in Lebanon.

1. Provide scores based on the current investment environment in Lebanon today.

2. Assume you have the opportunity to invest in a 50-100 MW on-shore wind farm.

3. Assume 1-6 MW class turbines from a quality manufacturer with a proven track record (eliminating certain technology risks).

4. Assume a build-own-operate (BOO) business model.

5. Assume a comprehensive O&M contract (eliminating certain technology risks).

6. Assume that transmission lines with free capacities and directly connected to the high-voltage grid of EDL are relatively close to the project site (within 10 km).

7. Assume an EPC sub-contractor, qualified for renewable energy, with high penalties for breach of contract (eliminating certain technology risks).

8. Assume a non-recourse, project finance structure.

Box 3: The eight investment assumptions for solar PV in Lebanon.

1. Provide scores based on the current investment environment in Lebanon today.

2. Assume you have the opportunity to invest in a 10-50 MW solar PV plant (eliminating certain technology risks).

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 (eliminating certain technology risks).

6. Assume that transmission lines with free capacities and directly connected to the high-voltage grid of EDL are relatively close to the project site (within 10 km).

7. Assume an EPC sub-contractor, qualified for renewable energy, with high penalties for breach of contract (eliminating certain technology risks).

8. Assume a non-recourse, project finance structure.

Box 4: The eight investment assumptions for Hydro power in Lebanon.

1. Provide scores based on the current investment environment in Lebanon today.

2. Assume you have the opportunity to invest in a 5-30 MW Run-of-river hydro projects.

3. Assume a High quality turbine manufacturer with experience in providing turbines for projects in developing countries and can supply the necessary technology for Lebanese conditions.

4. Assume a build-own-operate (BOO) business model.

5. Assume a comprehensive O&M contract (eliminating certain technology risks).

6. Assume that transmission lines with free capacities and directly connected to the high-voltage grid of EDL are relatively close to the project site (within 10 km).

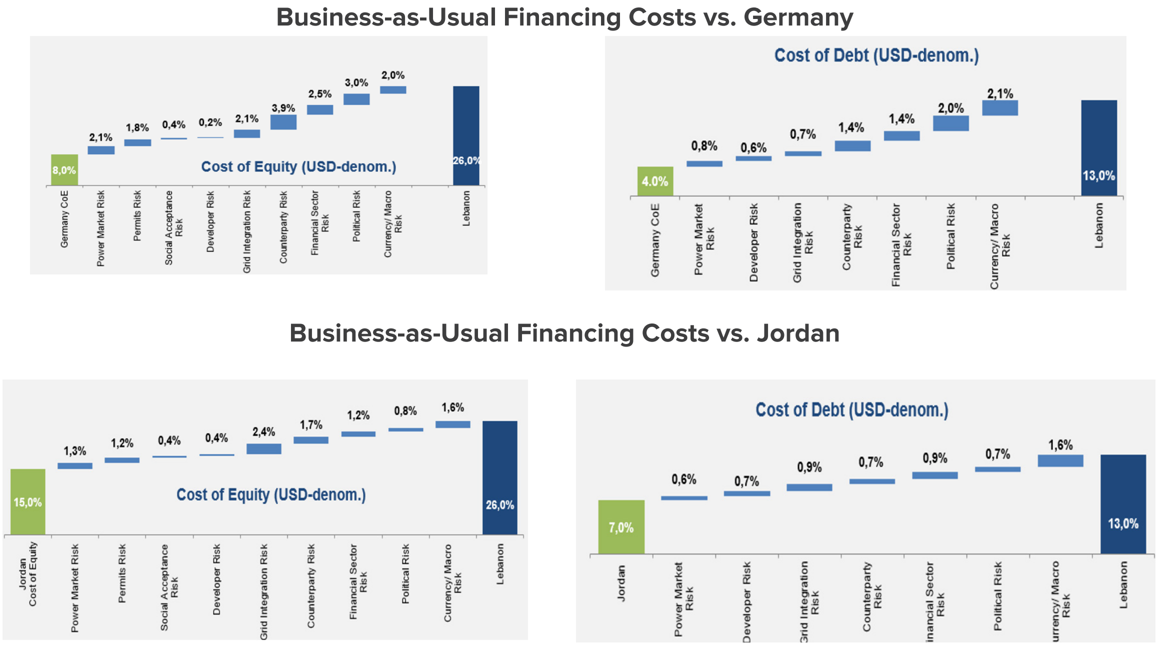
7. Assume an EPC sub-contractor, qualified for renewable energy, with high penalties for breach of contract (eliminating certain technology risks).

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 10 risk categories for equity investors. The ‘permits risk’ and ‘social acceptance” categories are removed for debt investors, assuming that FIs and banks will have prerequisites, such as having licenses, and most debt investors did not consider the social acceptance as a real impactful risk, before considering a funding request. As such, the modelling uses 8 risk categories for debt investors.
- The modelling selects Germany as the example of a best-in-class investment environment for wind energy, solar PV and hydro power. Germany is generally considered by international investors to have a very well-designed and implemented policy and regulatory regime, with minimal risk for all ten of the investment risk categories. In this way, Germany serves as the baseline – the left-most column of the financing cost waterfall.
- The modelling also selects Jordan as the example of the best-in-class investment environment for wind and solar PV in the region. Jordan is generally considered to have a well-designed and implemented policy and regulatory regime, with low risk for the region for all nine of the investment risk categories[90]. An additional model is added that serves a baseline for the left most column of the financing cost waterfall. A matrix was done based on the installed capacity in 2024 and already existing renewable energy capacity. Moreover, additional metrics were used like proximity to Lebanon, climate and political landscape.
- The Risk Environment Stage (Stage 1) differentiates between the answers from equity and from debt investors, but it does not distinguish further between investors with focus on wind energy, investors with focus on solar PV or hydro power. It is recognized that the risk profiles of large-scale wind energy, solar PV and hydro can differ, especially for ‘developer risk’. However, the results of the interviews with wind energy, solar PV and hydro power investors made clear that these differences are minimal in the Lebanese context. As such, the interview answers from equity and from debt investors were not further split into ‘wind energy focus’, ‘solar PV focus’ and ‘hydro power’ sub-groups, in order to bring simplicity to the analysis and to avoid multiple result sets. For the reader’s own judgment, the financing cost waterfalls that distinguish between answers from wind energy, solar PV and hydro power investors are shown.

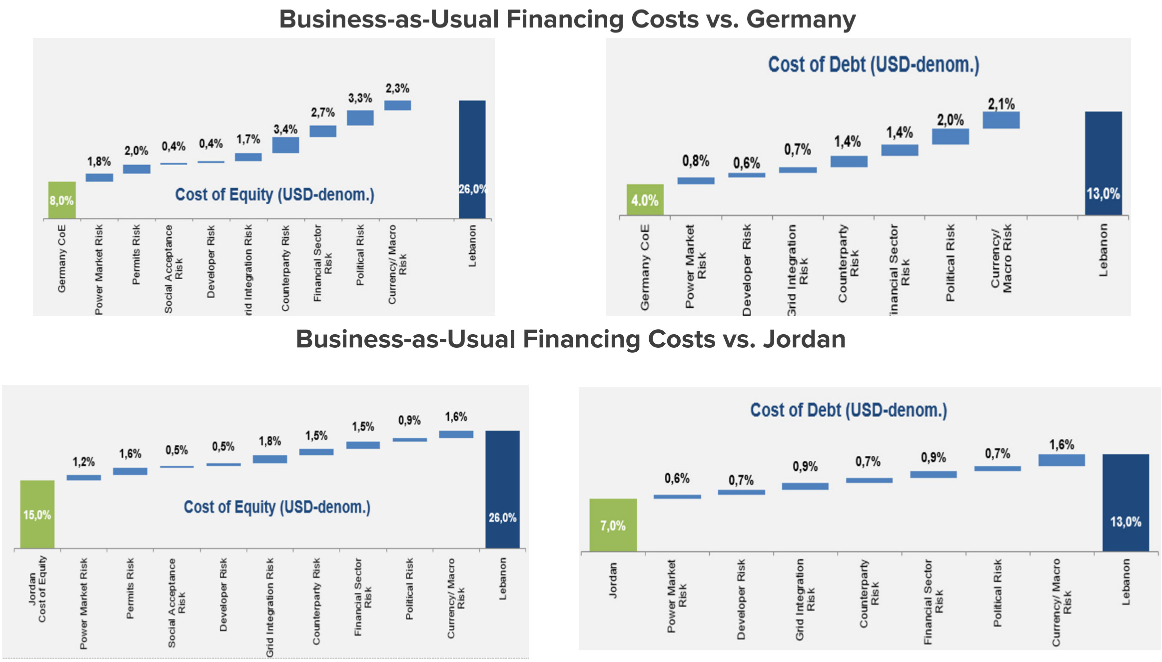
90 Climate risk attributed to hydro power is excluded for Jordan

Figure 29: Impact of risk categories on financing costs for wind energy investments in Lebanon, business-as-usual scenario.



Source: interviews with wind energy investors and developers; modelling

Figure 30: Impact of risk categories on financing costs for solar PV (utility and distributed) investments in Lebanon, business-as-usual scenario[91].

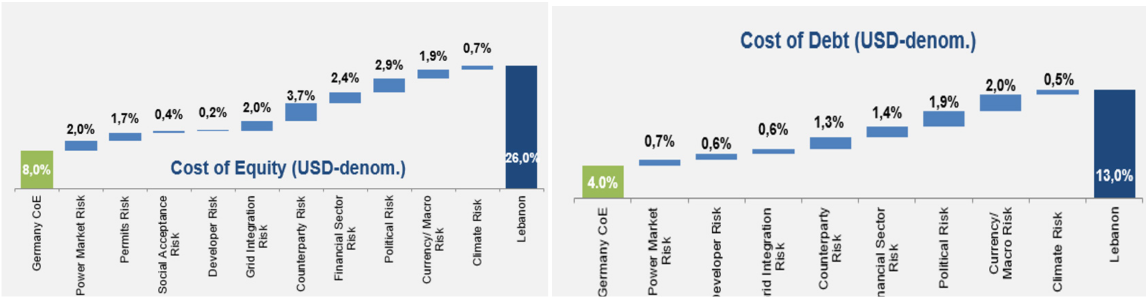


Source: interviews with solar PV investors and developers; modelling.

91 Investors in utility-scale solar PV projects are often also involved in mini-grid installations and perceive similar risks across both types of systems. In the context of Lebanon, key risks—such as permitting challenges (including legislative amendments like Law 318), currency volatility, and financial uncertainty—are considered equally relevant for both utility-scale and distributed renewable energy investments.

Figure 31: Impact of risk categories on financing costs for hydro power investments in Lebanon, business-as-usual scenario.

Business-as-Usual Financing Costs vs. Germany



C.2. Stage 2- Public Instruments

Public Instrument Table

The public instrument table for wind energy, solar PV and hydro power is derived from the generic table in the DREI report (2013, Section 2.2.1). The table is set out in full in Table 5 and includes the following modification:

- Following removal of fuel subsidies and investor feedback the set of policy derisking instruments for fossil-fuel subsidy reform (part of 'power market risk') is excluded from the modelling.
- To acknowledge the fact that Lebanon's energy crisis has produced a striving market for the sales of electricity from neighborhood-scale private generator networks, who may fear to be taken out of business by new RE installations, the table is amended by an additional barrier under 'social acceptance risk'. Some investors did share this concern, and consequently an exit plan from the government is added as an instrument was modelled that would address the barrier 'social and political resistance related to the (shadow) business of operating private generators during power outages'. This hold true for mostly mini-grid solar PV but also for utility scale projects.
- Financial derisking instruments addressing the 'hardware purchase and manufacturing' barrier under 'developer risk' were excluded from the modelling, as this barrier affects mainly locally manufactured hardware, which are not considered in the general investment assumptions (Boxes 2 and 3).
- Financial derisking instruments addressing the 'transmission infrastructure' barrier under 'grid & transmission risk', e.g., financial products to support grid infrastructure, are excluded in order to keep the modelling exercise manageable.
- Investor feedback revealed the 'currency/macroeconomic risk' to be of concern in Lebanon. Accordingly, the financial derisking instruments for this category (full indexing of PPA tariff) was modelled to a 100% indexing of PPA tariffs.
- Additionally, to reflect the evolving energy landscape following Lebanon's 2019 economic crisis, the modelling incorporates distributed solar PV as part of the baseline energy mix. Over the past five years, distributed solar—driven by private sector uptake—has become a significant contributor

to electricity supply, often surpassing generation from the national utility (EDL). Accordingly, both distributed solar PV and private diesel generators are included in the baseline scenario to accurately represent current market dynamics.

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 DREI report (2013, Section 2.2.2.). Each instrument has been modelled in terms of the costs of: (i) full-time employees (FTE) at mean yearly costs of USD 36,000 per FTE, and (ii) external consultancies/services at USD 180,000, USD 90,000, and USD 45,000 per large, medium, and small contract, respectively. An annual inflation of 2.5% is assumed for both FTE and consultancies/service contract costs. 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 up to the 5-year period from 2025 to 2030. See Tables 12, 13 and 14 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. The assumptions for the final effectiveness (after 5 years) are shown in Table 22. As certain policy derisking instruments may take time to become maximally effective, a linear ("straight-line") approach to time effects is modelled over the 5-year target investment period – this is referred to as the discount for time effects in the table. The qualitative investor feedback on policy derisking instruments' effectiveness is provided in Table 8 of the report.

Table 26: The modelling assumptions for policy derisking instruments' effectiveness.

Risk Category	Policy Derisking Instrument	Effectiveness	Discount for time effect	Comment
Power Market Risk	Streamline RFP process, establish well-regulated energy market, Regulatory authority.	60%	50%	Interview responses: Medium to high effectiveness.
Permits Risk	Streamline processes for permitting, establish contract enforcement and recourse mechanism.	75%	50%	Interview responses: High effectiveness.
Social Acceptance Risk	Awareness raising campaigns, community involvement, compensation and security concepts.	50%	50%	Interview responses: medium effectiveness.

Developer Risk	Building capacity for resource assessment, planning, construction, O&M, R&D.	35%	50%	Interview responses: low to moderate effectiveness.
Grid / Transmission Risk	Strengthen EDL's operational performance reg. grid management/grid code, policy support for grid infrastructure development.	60%	50%	Interview responses: moderate to high effectiveness.
Counterparty Risk	Strengthen EDL's management/ operational performance.	75%	50%	Interview responses: high effectiveness.
Financial Sector Risk	Financial sector policy reform, strengthen investors' familiarity with and capacity for renewable energy.	60%	50%	Interview responses: Medium to high effectiveness.
Political Risk	Government reforms, commitment to R.E, alternative funding sources.	50%	60%	Interview responses: Moderate effectiveness.
Climate Risk	Low climate impact technology and climate impact assessment	25%	25%	Interview responses: Low effectiveness.

Financial Derisking Instruments

The modelling assumptions for financial derisking instruments are informed by UNDP's in-house experience, including 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 Lebanon's envisioned 2030 RE targets 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 27 below.

Table 27: 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[92].	• Assumes 2.7% of annual production is lost due to grid management (curtailment) or transmission failures (black-out/brown-out). • Assumes 10% of IPP's lost revenues due to grid management or transmission failures are reimbursed by take-or-pay clause.
Counterparty Risk	Government (sovereign) Guarantee.	• Assumes the Lebanese Council of Ministers (or the Ministry of Finance) provides "Letter of Support" for each PPA entered into between EDL and the IPP. • The public cost of this type of guarantee are modelled as opportunity cost to GoL from setting aside 10 months worth of PPA payments at 8.6% cost of capital (public cost of capital of 13% minus 10y US Treasury bond rate of 4.4%).
Financial Sector Risk	Public Loan	• Assumes a mix of half concessional (4% and 20-year tenor) and half non-concessional (13% and 10-year tenor) USD loans from multilateral development banks to cover 50% of total debt needs (terms of mix: 5% and 10-year tenor). This is to assist developers in gaining access to capital and to win the commitment from the GoL. • Public cost: Assumes the public cost is 50% (loss reserve) of the face value of the loan to the IPP.
Currency Risk	Indexing to the dollar	• Assume 10% of hedging premium reflecting the economic cost of full FX coverage, ensuring a conservative model, realistic and bankable. • Assuming a 100% tariff index to hard currencies as indicated by most investors and experts.
Political Risk	Political Risk Insurance (PRI)	• Assumes 4 point MIGA-type coverage for equity holders covering expropriation, political violence, currency restrictions, and counterparty risk. • Covers 90% of the original face value of the equity invested (to reflect that not all IPPs might seek PRI and full coverage). • Public cost: • Assumes the public cost is 5% (loss reserve) of the equity amount covered. • Private cost: • Assumes a 70 basis points (0.7%) front end fee. • Assumes a 100 basis points (1%) premium payment, calculated annually.

- Effectiveness. Estimates for the effectiveness of financial derisking instruments in reducing

92 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.

financing costs are based on the structured interviews with investors. 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 26. The qualitative investor feedback on financial derisking instruments' effectiveness is provided in Table 6 of the report.

Table 28: The modelling assumptions for financial derisking instruments' effectiveness.

Risk Category	Financial Derisking Instrument	Effectiveness	Discount for time effect	Comment
Developer Risk	Financial product to gain access to capital funding.	25%	0%	Interview responses: medium effectiveness.
Grid/ Transmission Risk	Take-or-Pay Clause in PPA	60%	0%	Interview responses: high effectiveness, but already factored in (considered a pre-requisite in any PPA).
Counterparty Risk	Government (sovereign) Guarantee.	70%	0%	Interview responses: High effectiveness.
	Public Loan	70%	0%	Interview feedback: public "buy-in", especially from international donors, reduces also counterparty risk.
Financial Sector Risk	Public Loan	50% [Impact via concessional interest rates]	0%	Interview responses: high effectiveness.
Political Risk	Political Risk Insurance (PRI)	70%	0%	Interview responses: high effectiveness. However, only few projects might afford PRI, especially post-war.

C.3. Stage 3- Levelized Costs

Levelised Cost of Electricity (LCOE) Calculation

The DREI report's (2013 and 2018) 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 5 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 5: The modelling LCOE formula.

$$\frac{\%\,Equity\ Capital * Total\ Investment + \sum_{t=1}^{T} \frac{(O\&M\ Expense)_t + (Debt\ Financing\ Costs)_t - Tax\ Rate * (Interest\ Expense_t + Depreciation_t + O\&M\ Expense_t)}{(1 + Cost\ of\ Equity)^t}}{\sum_{t=1}^{T} \frac{Electricity\ Production_t * (1 - Tax\ Rate)}{(1 + Cost\ of\ Equity)^t}}$$

Where,

% Equity Capital = portion of the investment funded by equity investors

O&M Expense = operating & 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 100% of fixed assets over the lifetime of investment is used. The standard corporate tax rate for Lebanon at 17% was used. No tax credits, or other tax treatment, are assumed.

Baseline Energy Mix Levelized 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 combined baseline approach is used on the basis that Lebanon's power sector is on the one hand characterized by notorious under-supply and rapidly increasing energy demand. As such, new wind energy, solar PV and hydro power installations will likely not replace existing generation capacity. On the other hand, Lebanon's existing power plant fleet is old and inefficient. While some plants might need to be taken offline in lieu of new generation capacity.
- A number of assumptions and simplifications are made in order to keep the modelling exercise manageable, while at the same time adequately reflecting Lebanon's current power generation mix. Based on, the amount of energy produced by the different installations, as provided by the MoEW for the year 2025, this mix is split into three sub-groups[93]:
  - CCGT plants running on Gas oil ('CCGT on LFO'). These are the two plants Deir Aamar at the North Lebanon shore, and Zahrani at the South Lebanon shore. The open cycle gas turbines (OCGT) plants of Tyre and Baalbek are also included in this group.
  - Private residential generators running on light fuel oil ('LFO').
  - Thermal plants (Zouk, Jiyeh, Hrayche), private industrial generators all running on heavy fuel oil ('HFO'). The reciprocating power plants in zouk and Jiyeh are also included in the energy mix.
  - Private (Mini-grid) solar PV installation that adds up to 1,400 MWp are part of the basline energy mix as they make up a big part of energy production prior to 2019 crisis.
  - Hydro power IPPs that are already installed in Lebanon, taking into account the deratted capacity of the plants.
- Assumptions for the distributed solar PV with and without storage are the same, taking diesel generators as our only baseline energy based on the DREI 2018 off-grid model.
- The modelling assumptions for these four sub-groups of the operating baseline technology mix are shown below in Table 29.

93 Lebanon's hydro power plants are not considered in this marginal baseline approach, since they account for only 2.5% of the electricity generated in 2015, and they would not be replaced by new renewables.

Table 29: The modelling assumptions for the baseline energy mix technology.

Technology Item	Assumption						Source/Comments
	CCGT on light fuel	OCGT on light fuel	Hydro	Heavy fuel	Solar PV distributed	Genset	
Share of generation mix	35.0%	1.0%	4.0%	25.0%	9.0%	26.0%	MoEW statistics for the year 2015.
Investment cost (USD/MWel)	0						Authors, Lebanon's fossil fuel fired power plants are old and considered depreciated.
Current O&M cost excl. fuel (USD/MWel)	$35,000	$35,000	$18,000	$40,000	$15,000	$40,000	Authors, based on DREI report (2013), also based on extensive research. Heavy fuel oil plants are old and need extensive O&M to operate. Genset needs extensive O&M as well.
O&M Inflation	2.0%						Authors, O&M inflation of 2% until 2030.
Lifetime (years)	10	10	15	10	15	15	Authors, expert overview.
System Efficiency	47.3%	30.5%	96.0%	34.6%	20.0%	33.0%	Authors, based on MoEW statistics and the actual EDL and MoEW data between 2019 and 2023.
Capacity Factor	84.4%	25.3%	65.0%	61.8%	16.0%	42.1%	MoEW experts, Authors, UNDP and based on real time plants workload and capacity over an average of 5 years between 2019 and 2023.

Emission Factor	0.691 tCO_2e/MWh						MoEW statistics (emission factors are aggregated for all assets except hydro; only direct emissions from assets are considered), data from UNFCCC published documents, and calculations by KPMG based on the average emissions of each fuel type over three consecutive years.
Financing Item							
Capital structure	100% EDL owned	100% EDL owned	100% IPPS through EDL	100% EDL owned	100% private owned	100% private owned	Authors, based on MoEW data and experts' input.
Cost of equity	22.1%	22.1%	22.1%	22.1%	22.1%	22.1%	Same as for RE, 4% discounted to account for market maturity for respective plants.
EDL's cost of capital	7%	7%	7%	7%	-	-	Same as public cost of capital (EDL is state owned).
Depreciation allocation	Straight line, 100% depreciable						Authors

- Fuel prices have been obtained from World Bank projections for the gas price and from Energy Information Agency projections for light fuel oil and heavy fuel oil prices. According to these projections, the 2025 starting values of 105.5 USD/MWh, 180.0 USD/MWh, and 130.0 USD/MWh for Gas oil, Gas oil (OCGT), and heavy fuel oil, respectively, would increase by 1% year on year until 2030.
- For distributed solar PV (mini-grid) systems, the baseline energy mix in the model is limited to diesel generators typically used in rural villages. As a result, the modeling assumptions for mini-grids mirror those applied to diesel generators in the utility-scale energy mix. However, the mini-grid model includes additional inputs—such as detailed operating costs, equipment specifications, and distribution infrastructure—which are not captured with the same level of granularity in the utility-scale energy mix modeling. Assumptions are included in Table 30 below.

Table 30: The modeling assumptions for Diesel generator baseline energy.

Diesel Baseline	Assumption	Source/Comments
Maximum Load	27.6 kW	Authors
Safety Factor	15% kW	Authors
Diesel Generator Capacity	31.8 kW	Authors/ load plus safety factor.
Lifetime of Investment	20 years	Authors
Cost of Diesel Generator	400 USD/kW	Authors/Global benchmark and generator owners In Lebanon.
Lifetime of generator (runtime)	5,000 hours	Authors/ Typical for rural mini-grids with basic infrastructure.
Installation cost	320 USD/end-user	Authors/ Basic connection for a generator in Lebanon.
Minimum Load for Generator	35%	Authors (only direct emissions from RE asset are considered).

Wind Energy – Technology specifications

The technical assumptions for the wind energy LCOE calculation are set out in Table 31 below.

Table 31: The modelling assumptions for wind energy technology specifications.

Technology Item	Assumption	Source/Comments
2030 wind energy installed capacity	226 MW	Permits given by the MoEW for Hawa Akkar.
Turbine size	3-6 MW class	Authors/UNDP
Park size	50-100 MW	Authors/UNDP
Core investment costs, including balance of plant costs (civil works, transformers), 2025 Cost	1,600,000 USD/MW	IRENA_Power Generation Costs 2020.pdf (apren.pt); 1624710906-renewable-power-generation-costs-in-2020-irena.pdf. IRENA, 2020: World average of 2025(1,600,000 USD/MW) as projected by IRENA, this results considering the wind farms will be built in the coming 5 years.
Annual O&M costs at start of operation Annual increase	32,000 USD/MW 2%	Lebanese project developers, O&M costs using IRENA projection (IRENA, 2020);
Lifetime	20 years	Authors.
Wind energy capacity factor	31.05%	Area-weighted average from IRENA reports and Lebanon wind atlas.
Emission Factor	0 tCO_2e/MWh	Authors (only direct emissions from RE asset are considered).

Solar PV – Technology specifications

The technical assumptions for the solar PV LCOE calculation are set out in Table 32 below.

Table 32: The modelling assumptions for solar PV technology specifications.

Technology Item	Assumption	Source/Comments
2030 solar PV installed capacity	330 MW	Based on the 12 permits for utility scale solar projects in Lebanon.
Solar PV technology	C-Si	Authors
Park size	10-50 MW	Authors
Core investment costs, including balance of plant costs (civil works, transformers), 2023 Cost	550,000 USD/ MW	Investor in Lebanon, total cost of 165 MW park envisioned in Lebanon.
Annual O&M costs At start of operation Annual increase	13,000 USD/ MW 2%	Lebanese project developers, O&M costs from Renewable energy foundation, O&M cost are significantly lower for Solar PV as the market matured.
Lifetime	20 years	Authors
Solar PV capacity factor	19.83%	Area-weighted average from NREAP (MoEW, 2024).
Emission Factor	0 tCO_2e/MWh	Authors (only direct emissions from RE asset are considered).

Hydro power – Technology specifications

The technical assumptions for the Hydro power LCOE calculation are set out in Table 33 below.

Table 33: The modelling assumptions for ydro power technology specifications.

Technology Item	Assumption	Source
2030 hydro power installed capacity	58 MW	Based on 2021 Least Cost of Energy Plan project to add hydro power, UNDP.
Hydro power (run-of-river) technology	Pelton turbines	Authors, UNDP.
Park size	30-50 MW	Authors, UNDP.
Core investment costs, including balance of plant costs (civil works, transformers), 2023 Cost	1,800,000 USD/ MW	Based on IRENA cost projection for run-of-river projects.
Annual O&M costs At start of operation Annual increase	18,000 USD/ MW 2%	Lebanese project developers, O&M costs extrapolated from IRENA projection.
Lifetime	50 years	Authors
Hydro power capacity factor	58%	Area-weighted average from NREAP (MoEW, 2024).
Emission Factor	0 tCO_2e/MWh	Authors (only direct emissions from RE asset are considered).

Distributed Solar PV – Technology specifications

The technical assumptions for the distributed solar PV LCOE calculation are set out in Table 34 and Table 35 below.

Table 34: The modelling assumptions for solar PV with storage technology specifications.

Technology Item	Assumption	Source
2030 Solar PV installed capacity	1,200 MW	Based on discussion with UNDP.
Solar PV technology	C-Si	Authors, UNDP
Mini-grid size	0.1 - 10 MW	Authors, UNDP
Core investment costs and distribution cost (total cost including labor)	• Solar PV modules = 150 USD/kWp • Inverter = 80 USD/kWp • BOS = 8% of the cost • Ion Lithium Batteries = 200 USD/kWp Distribution cost: • LV cost = 5,000 USD/km • Transformer = 6,000 USD/unit • End user cost (labor + wires) = 160 USD/end-user	Investor in Lebanon and solar PV contractors.
Annual O&M costs At start of operation Annual increase	1% of the total investment 2% yearly inflation	Lebanese project developers, O&M costs extrapolated from IRENA projection.
Lifetime	20 years	Authors
Emission Factor	0 tCO_2e/MWh	Authors (only direct emissions from RE asset are considered).
Battery storage capacity	6 hours of supply	As agreed with the UNDP team.

Table 35: The modelling assumptions for solar PV without storage technology specifications.

Technology Item	Assumption	Source
2030 Solar PV installed capacity	1,200 MW	Based on discussion with UNDP.
Solar PV technology	C-Si	Authors, UNDP.
Mini-grid size	0.1 - 10 MW	Authors, UNDP.
Core investment costs, including balance of plant costs (civil works, transformers), 2023 Cost	• Solar PV modules = 150 USD/kWp • Inverter = 80 USD/kWp • BOS = 8% of the cost Distribution cost: • LV cost = 5,000 USD/km • Transformer = 6,000 USD/unit • End user cost (labor + wires) = 160 USD/end-user	Investor in Lebanon and solar PV contractors.

Annual O&M costs At start of operation Annual increase	1% of the total investment 2% yearly inflation	Lebanese project developers, O&M costs extrapolated from IRENA projection
Lifetime	20 years	Authors
Emission Factor	0 tCO_2e/MWh	Authors (only direct emissions from RE asset are considered).
Battery storage	No storage	As agreed with UNDP team.

Wind Energy, Solar PV and hydro power – Terms of Finance

The financial assumptions used for wind energy, solar PV (utility and distributed) and hydro power LCOE modelling are set out in Table 36 below.

Table 36: The modelling assumptions for wind energy, solar PV and hydro terms of finance.

Finance Item	Assumption		Source/Comments
	BAU	Post-derisking	
Capital structure	100% equity, 0% commercial loan.	30% equity, 70% commercial loan.	Authors
Cost of equity	26%	19.8%	Based on CapM model and this study findings.
Debt structure	100% commercial loan.	25% concessional public loan, 75% commercial loan.	Authors.
Loan terms	Commercial: 0%, 10-year tenor.	Concessional public: 5%, 10/25-year tenor, Commercial: 8.9%, 10/25-year tenor.	Commercial: Lebanese investors, concessional: authors 10 years for solar and wind energy, 25 years tenor for hydro power.
Depreciation allocation	Straight line, 95% depreciable.		Authors (5% non-depreciable reflects land).
Distributed Solar PV			
Capital structure	100% equity, 0% commercial loan.	50% equity, 50% commercial loan.	Authors
Cost of equity	26%	19.5%	Based on CapM model and this study findings.
Debt structure	100% commercial loan.	50% concessional public loan, 50% commercial loan.	Authors
Loan terms	10-year tenor	10-year tenor	
Depreciation allocation	Straight line, 95% depreciable.		Authors (5% non-depreciable reflects land).
Tax and Tariffs	0% import tax and 0% tariffs on green technology material.		As per the Lebanese Law.

Wind Energy, Solar PV and Hydropower – Grid Interconnection Costs

Grid interconnection costs are also included in the LCOE for wind energy, solar PV and hydro power. The modelling assumes that all wind energy, solar PV and hydro power plants are within 10 km of the power grid (see Boxes 2 and 3).

The assumptions used for grid interconnection costs are set out in Table 37 below.

Table 37: The modelling assumptions for utility wind energy, solar PV and hydropower grid interconnection costs.

Finance Item	Assumption	Source/Comments
Cost per km of Individual 90kV Transmission Line.	USD 150,000	Renewable energy grid forum and Lebanese grid expert.
Number of Transmission Lines (Redundancy).	2	Authors
Typical length of Transmission Line.	10 km	Authors (as defined in General Investment Assumptions).
Typical size of wind energy, solar PV or hydro power plant.	30 MW	Authors
Cost of Sub-Station (1 per wind energy or solar PV plant).	USD 2,000,000	Lebanese grid expert and Lebanese electric engineers.
Distributed Solar PV		
Low Voltage Distribution Line, Cost.	USD 5,000	Renewable energy grid forum and Lebanese grid expert.
Typical PV module size of mini- grid for 50 households.	100 kWp	Based on the demand of 417 kWh/day.
Number of modules used.	250	Solar yield is around 5.5 kWh/kWp/Day and this include not only household but some other facilities plus 0.75 performance ratio accounting for system losses.
Battery lithium ion size fore a maximum load of 27.6 kW and calendar lifetime of 7 years.	200 kWh	6 hours of storage to serve the load of 417 kWh/day.

The solar PV mini-grid is designed to serve a small village in Lebanon, providing reliable and sustainable electricity to approximately 80 end users. The system will supply power to households, a municipal building, a school, a clinic, and street lighting infrastructure, covering essential community needs. The mini-grid aims to enhance energy access, reduce reliance on diesel generators, and support local development through clean and affordable electricity.

C.4. Stage 4 - Evaluation

Wind Energy, Solar PV and Hydropower Sensitivities

The modelling performs three types of sensitivities for wind energy, solar PV and hydro power.

Table 38 below sets out the assumptions and sources used for the sensitivities to key input assumptions, namely investment costs, O&M cost, capacity factor, fuel costs and financing costs (sensitivities of Type 1 in main report).

Table 38: The modelling approach to sensitivities of key input assumptions for wind energy, solar PV and hydro power.

Sensitivity	Assumptions/Approach	Source/Comment
Investment Costs	Wind energy Base case: 1,600,000 USD/MW Sensitivity: 1,800,000 USD/MW Solar PV: Base case: 550,000 USD/MW Sensitivity: 700,000 USD/MW Hydro power: Base case: 1,800,000 USD/MW Sensitivity: 2,000,000 USD/MW	Base Case: Refer to Table 27, Table 28, and Table 29, based on IRENA reports for wind, solar PV, and hydropower, as well as expert input. The cost of solar PV is estimated to range between USD 500,000/MW and USD 700,000/MW, depending on the contractor, panel specifications, and technology used—based on interview insights. For mini-grids, cost sensitivity assumes a 10% increase from the base case outlined in Table 34 and Table 35. Sensitivity Analysis: IRENA sources estimate costs between USD 700,000/MW and USD 1.2 million/MW, influenced by land and technology factors. In Lebanon, most permits are in the Bekaa region, where land is relatively inexpensive. Permits in the south, however, involve higher land costs. Consequently, costs could reach USD 850,000/MW when projecting for top-quality panels. Similar estimates apply to wind and hydropower, with an additional 15% adjustment based on IRENA reports, which attribute higher costs to turbine quality.
O&M Costs	Wind energy Base case: 32,000 USD/MW Sensitivity: 40,000 USD/MW Solar PV: Base case: 13,000 USD/MW Sensitivity: 20,000 USD/MW Hydro power: Base case: 18,000 USD/MW Sensitivity: 22,000 USD/MW	O&M assumptions are based on IRENA reports and expert input for wind, solar PV, and hydropower. For mini-grid solar PV investments, O&M is considered as a percentage of the total cost, set at 1%.

Capacity Factor	Wind energy: Base case: 31% Sensitivity: 35% Solar PV energy: Base case: 20% Sensitivity: 24% Hydro power: Base case: 50% Sensitivity:58 %	Wind energy: Authors, informed by the NREAP, note that 30% is the area-weighted average capacity factor in Lebanon when wind speeds below 7.5 m/s and above 9.5 m/s are excluded. For Hawa Akkar and the considered permits, the average capacity factor would be around 40%; however, a conservative value was adopted. Solar PV: Capacity factors in Lebanon range between 18% and 22%, based on regional solar irradiance data (1,800–2,200 kWh/m^2/year). In the Bekaa region, solar irradiance is higher, and capacity factors can reach up to 24%. Hydro power: A capacity factor of 50% is assumed. According to the EIA, the average capacity factor for existing hydroelectric plants is between 40% and 55%. Based on EDL data from 2012 to 2022, the average capacity factor for Lebanon's existing hydro fleet is approximately 28%.
Fuel Costs	Wind energy, solar PV and hydro power: +/- 20% difference to WB (gas) and EIA (LFO, HFO) fuel cost forecasts	Authors
Financing Costs	Wind energy, solar PV and hydro power: +/- 1% difference on financing costs from interviews	Authors

For the sensitivities to different instrument packages (Type 2 in main report), the following sub-sets of derisking instruments were considered (see Table 3 or Table 5 for an overview over all risks and instruments):

- Scenario 'policy derisking only' considers exclusively policy derisking instruments. They address power market risk, permits risk, social acceptance risk, developer risk, grid/transmission risk, counterparty risk, and financial sector risk.
- Scenario 'financial derisking only' considers exclusively financial derisking instruments. They address gird/transmission risk, counterparty risk, financial sector risk, and political risk.
- Scenario 'high impact risks' considers both policy and financial derisking instruments addressing power market risk, grid/transmission risk, counterparty risk, political risk. Public loans are not modelled in this scenario, despite their small effectiveness attributed to counterparty risk.

Table 39 below sets out the assumptions used for the sensitivities to two additional approaches for financial instrument costing, namely a more conservative and a more aggressive approach (sensitivities of Type 3 in main report)[94] .

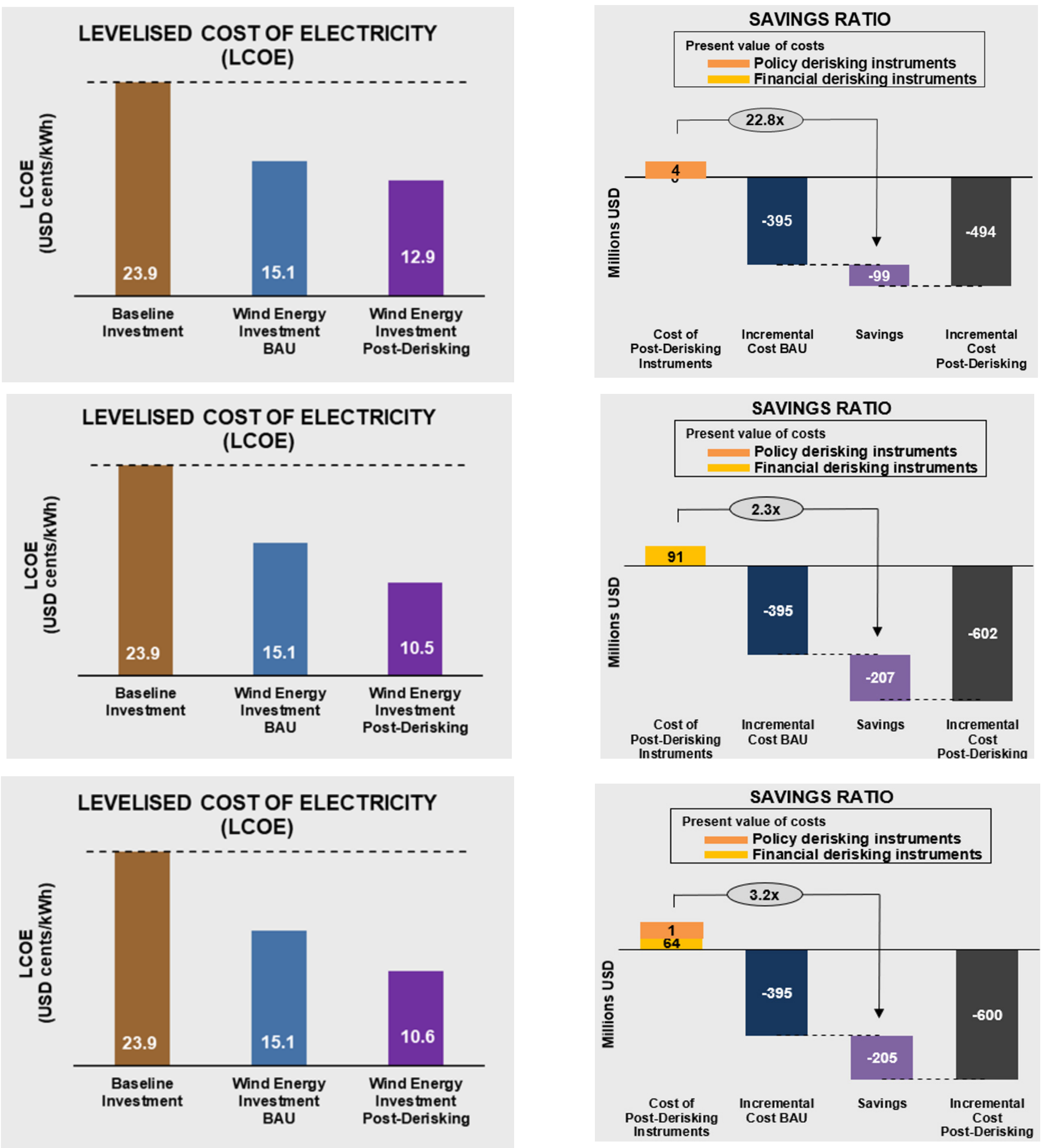
94 This sensitivity for the public loans is only available for utility scale energy project

Table 39: The modelling approach to sensitivities for the costing of utility scale technologies financial derisking instruments.

Sensitivity	Assumptions/Approach	Comment
Public cost associated to "Letter of support" from GoL to guarantee PPA	Base case: opportunity cost for setting aside 10 months worth of PPA payment at 5% cost of capital Conservative approach: 100% of 10 months worth of PPA payments Aggressive approach: no public cost	Conservative approach: assumes that EDL defaults to pay the IPPs during a total of 10 months over the lifetime of the project. Aggressive approach: assumes that no public costs are attributed to such a letter Full Indexing is assumed for all scenarios.
Public loan loss reserve [% of face value to IPP]	Base case: 25% Conservative approach: 100% Aggressive approach: 0%	Conservative approach: corresponds to the unlikely case that all of the borrowers will default. Aggressive approach: assumes that loans are fully reimbursed by the end of the tenor. Full Indexing is assumed for all scenarios.
Political risk insurance loss reserve [% of equity amount covered]	Base case: 100% Conservative approach: 100% Aggressive approach: 100%	Conservative approach: Full equity amount allocated as loss reserve. Aggressive approach: only PRI reserve allocated. Full Indexing is assumed for all scenarios.

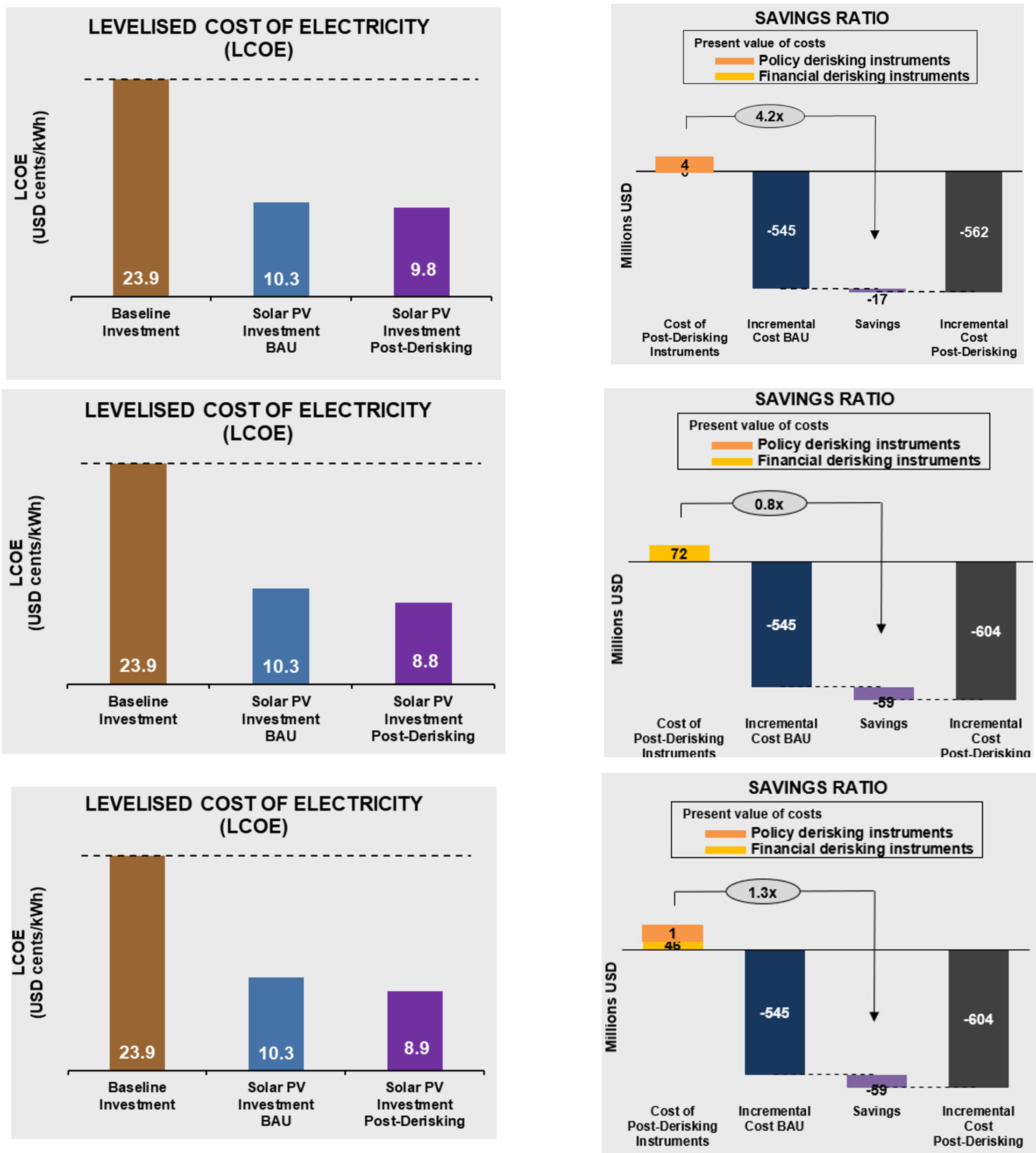
Annex B. Graphical Representation Of Sensitivity Analyses

Figure 33: Wind energy: summary of LCOE (left) and savings ratio (right) outputs for sensitivity analyses considering only policy derisking instruments (top row), only financial derisking instruments (middle row), and only instruments targeting the five risk categories having the highest impact on financing cost (permit risk, grid/transmission risk, counterparty risk, political risk and currency risk).



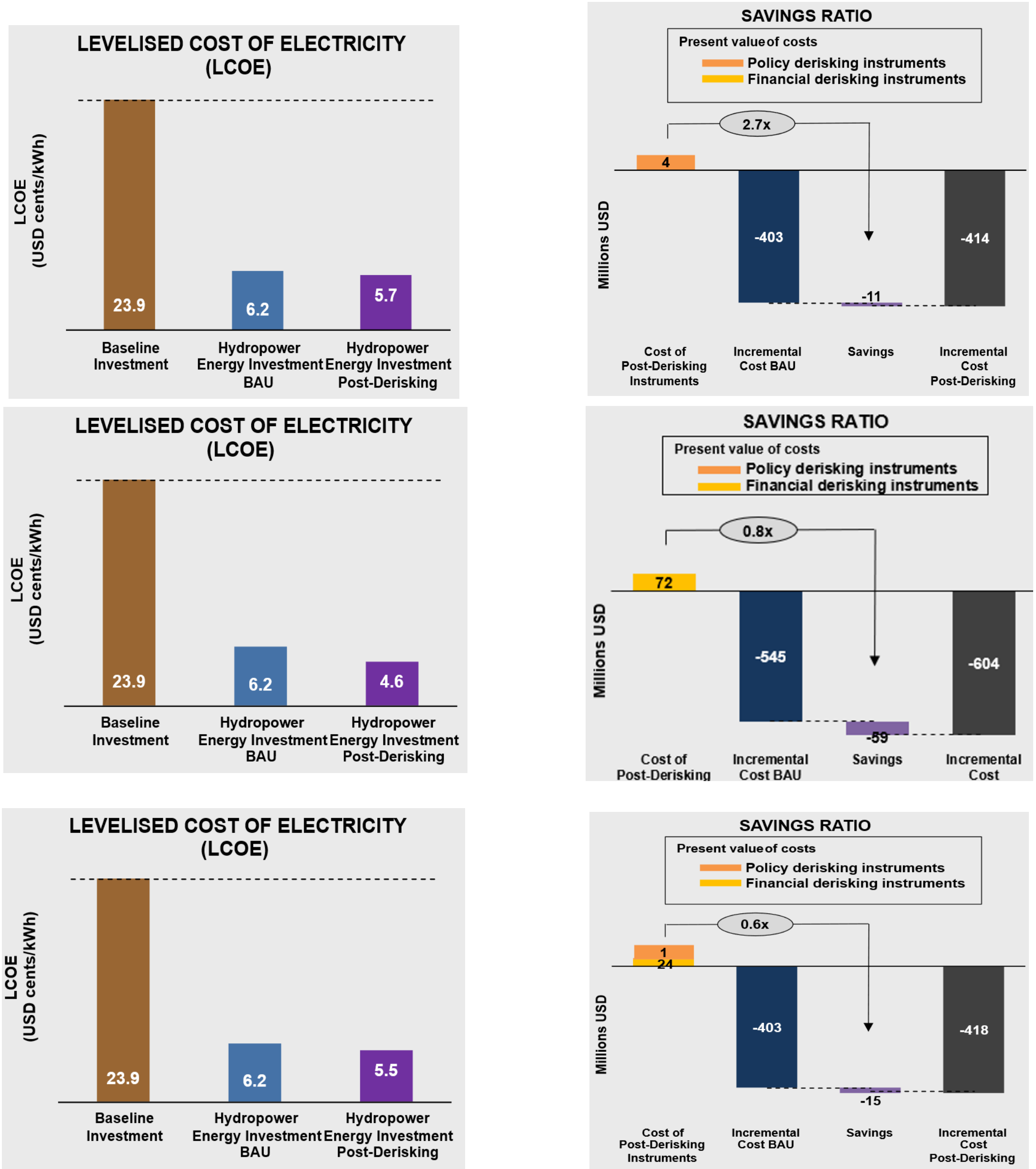
Source: sensitivity modelling; see Figure 22 for base case scenario, see Table 31 and Annex A for details of assumptions and methodology.

Figure 34: Solar PV: summary of LCOE (left) and savings ratio (right) outputs for sensitivity analyses considering only policy derisking instruments (top row), only financial derisking instruments (middle row), and only instruments targeting the five risk categories having the highest impact on financing cost (permit risk, grid/transmission risk, counterparty risk, political risk and currency risk).



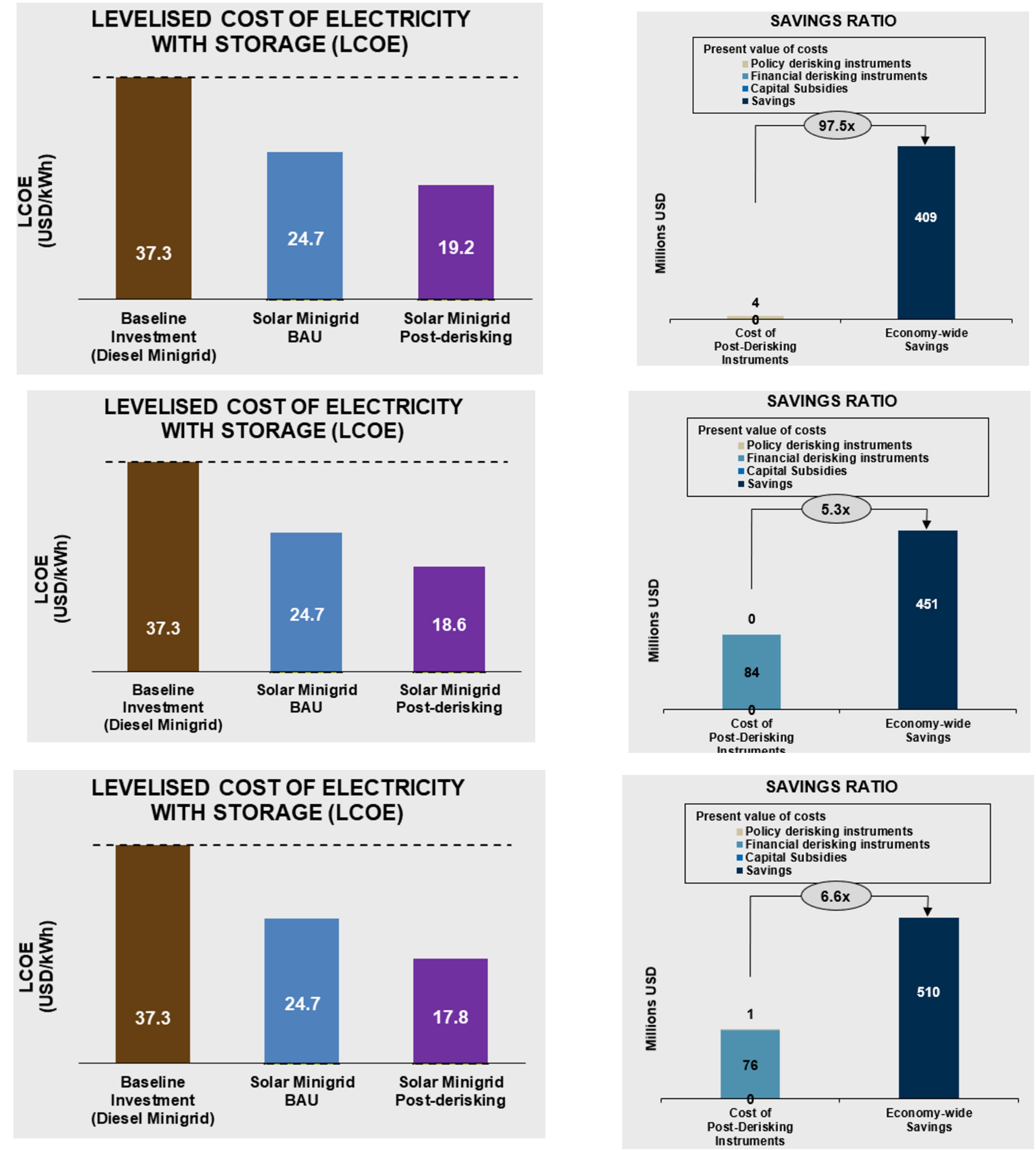
Source: sensitivity modelling; see Figure 23 for base case scenario, see Table 32 and Annex A for details of assumptions and methodology.

Figure 35: Hydro power: summary of LCOE (left) and savings ratio (right) outputs for sensitivity analyses considering only policy derisking instruments (top row), only financial derisking instruments (middle row), and only instruments targeting the five risk categories having the highest impact on financing cost (permit risk, grid/transmission risk, counterparty risk, political risk and currency risk).



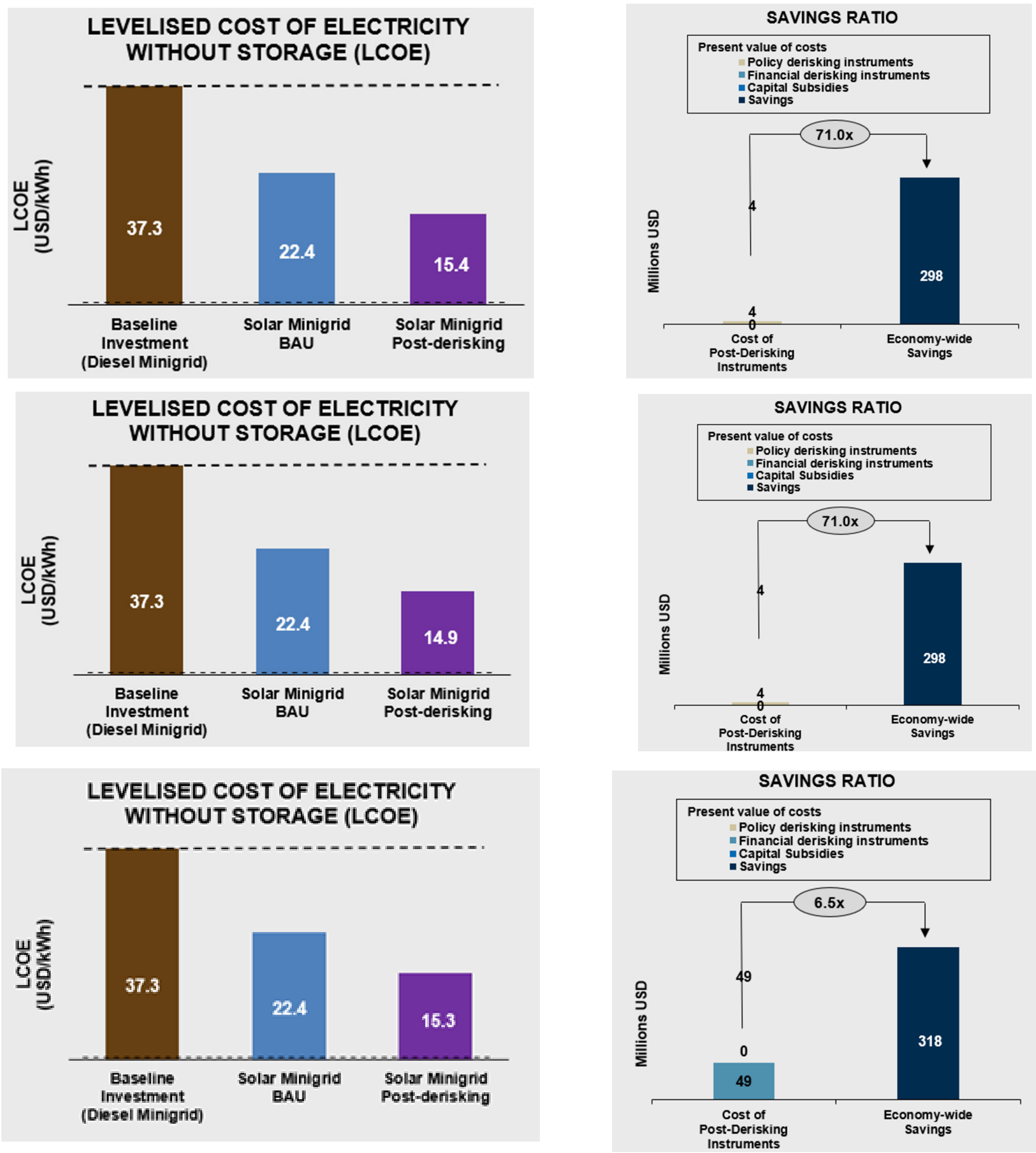
Source: sensitivity modelling; see Figure 24 for base case scenario, see Table 33 and Annex A for details of assumptions and methodology

Figure 36: Distributed solar PV with storage: summary of LCOE (left) and savings ratio (right) outputs for sensitivity analyses considering only policy derisking instruments (top row), only financial derisking instruments (middle row), and only instruments targeting the five risk categories having the highest impact on financing cost (permit risk, grid/transmission risk, counterparty risk, political risk and currency risk).



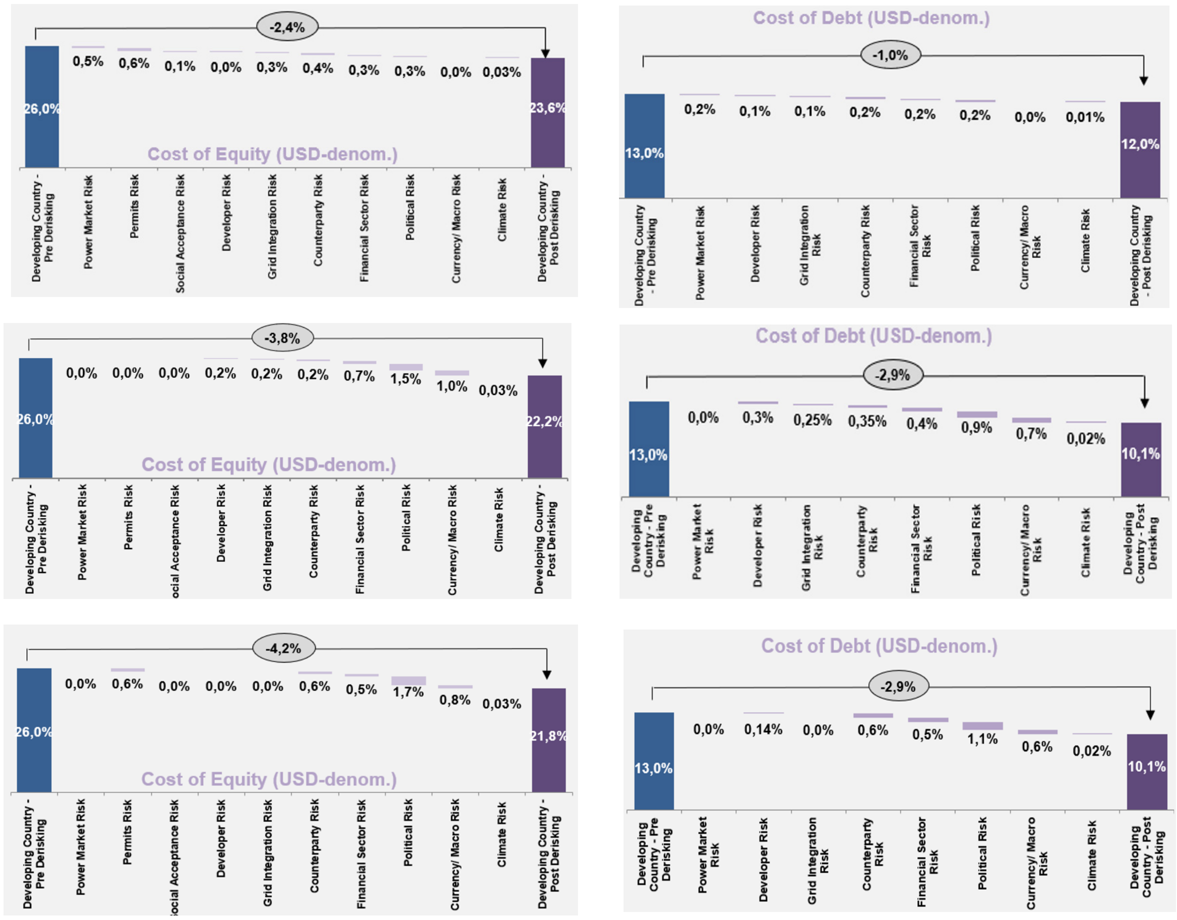
Source: sensitivity modelling; see Figure 25 for base case scenario, see Table 34 and Annex A for details of assumptions and methodology

Figure 37: Distributed solar PV without storage: summary of LCOE (left) and savings ratio (right) outputs for sensitivity analyses considering only policy derisking instruments (top row), only financial derisking instruments (middle row), and only instruments targeting the five risk categories having the highest impact on financing cost (permit risk, grid/transmission risk, counterparty risk, political risk and currency risk).



Source: sensitivity modelling; see Figure 26 for base case scenario, see Table 34 and Annex A for details of assumptions and methodology

Figure 38: Wind energy, solar PV and hydro power: Summary of impact on financing costs outputs for sensitivity analyses considering only policy derisking instruments (top row), only financial derisking instruments (middle row), and only instruments targeting the five risk categories having the highest impact on financing cost (permit risk, grid/transmission risk, counterparty risk, political risk and currency risk)



Source: interviews with wind energy, solar PV and hydro power investors and developers; modelling; see Figure 19 for base case scenario, see Annex A for details of assumptions and methodology. Note: the impacts shown are average impacts over the 2025-2030 modelling period, assuming linear timing effects.

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