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EvD
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Knowledge Paper

Key lessons for green energy systems:

Insights from Independent Evaluation

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Executive Summary

Globally, the energy sector is transforming rapidly. The green transition and the urgency of addressing the climate crisis is leading to significant changes in how energy systems operate. Lessons from evaluation can provide a valuable perspective on how to develop green energy systems that are sustainable, secure and affordable.

This paper focuses on providing evidence-based insights from evaluation on two central themes: the technical integration of intermittent renewable energy and building markets to set the right incentives. At the core of the green energy transition will be low-cost, renewable energy such as wind and solar. Whilst affordable and sustainable, these mechanisms for generating energy create new technical challenges due to the intermittency of generation. The cost profile of renewable technology, the dynamism within the sector, and the intermittency factor also requires structural changes in how markets operate and generate incentives.

The technical integration of intermittent renewable energy is the critical foundation for the green energy transition. Intermittent and fluctuating energy generation is challenging for grid operators, with respect both to grid infrastructure and developing an appropriate mix of power sources. Evaluations have consistently focused on the need to balance investments between renewable energy generation and transmission infrastructure, in order to ensure that grids have the capacity to accommodate intermittent energy generation.

Looking forward, policy-makers will have access to an increasingly diverse range of tools to support integration. Increasing electrification, energy storage mechanisms, and smart grids will provide new opportunities to support the integration of intermittent renewable energy. However, evaluations have also demonstrated the continuing role that hydrocarbon sources of power generation might play in some contexts, in providing balancing services which support the integration of intermittent energy.

Markets will need to evolve in tandem with the physical infrastructure of energy systems. Evaluations have shown that a market approach to energy systems which combines private sector investment with public sector oversight is critical to a successful green transition. The rapid increase in renewable energy capacity also necessitates a systemic approach to ensure appropriate risk mitigation. Dynamic markets enable risk to accumulate quickly, particularly if policy and regulatory regimes remain static despite evolving market circumstances.

The interaction between electricity markets and renewable energy generators may also have to change. In more mature markets, moving away from the security of price stability and guaranteed off-take could support more flexible, secure and affordable energy systems. Addressing constraints on investment is also critical, particularly given the cost profile of renewable energy generation and the outsized influence that the cost of capital has on the cost of energy generation.

1 Introduction

Globally, energy systems are transforming. Technological advances in green energy generation, such as in solar and wind, are driving change, underpinned by the growing awareness of the climate emergency and the necessity of limiting CO_{2e} emissions.

This EvD knowledge product draws lessons from the evaluations produced by Multi-Lateral Development Banks (MDBs) on their approaches to energy systems, supplemented with EBRD data and strategic documents outlining how MDBs approach energy systems[1]. It does not involve primary data collection, nor an assessment of performance.

2 Objectives, approach and structure

The objective of this paper is to provide insights from evaluation on how to support the transition to green energy systems. For benchmarking what an optimal green energy system looks like, this approach uses the framework of sustainable, secure and affordable energy systems developed by the World Energy Council. This concept has been adopted by several MDBs, including the EBRD[2], ADB[3], and AfDB[4] in defining their approach to the Energy Sector.

Box 1: Unpacking the framework of an optimal energy system

- **Sustainable energy** refers to green, low-carbon energy generation, as well as the sustainability of other environmental assets and social sustainability.
- **Energy security** has multiple dimensions, including the reliability of supply, vulnerability to price shocks, resilience of physical energy infrastructure, diversification of energy sources, and reliance on foreign energy resources.[5].
- **Affordability** is access to energy at an affordable rate for consumers, businesses, and governments. The widespread use of subsidised energy rates can also obscure the cost of energy as well as who is shouldering the burden.

This paper is structured around two central concepts:

- **Supporting the technical integration of intermittent renewable energy** – a critical foundation for the green transition
- **Building markets to promote green energy –** getting the incentives right

These two concepts are interdependent. The technical requirements of intermittent energy generation have implications for market structure, whilst market structures will also incentivize stakeholders to adopt different solutions to the intermittency challenge.

3 Supporting the integration of intermittent renewable energy: a critical foundation for the green transition

Two of the most prominent renewable energy technologies – solar and wind – are intermittent, meaning that energy production is not constant. This creates challenges for national grid operators, who must ensure that they have the infrastructure and tools necessary to accommodate intermittent energy generation, and to balance fluctuations in power generation.

Figure 1: Renewable Energy generation varies on a seasonal basis[6]

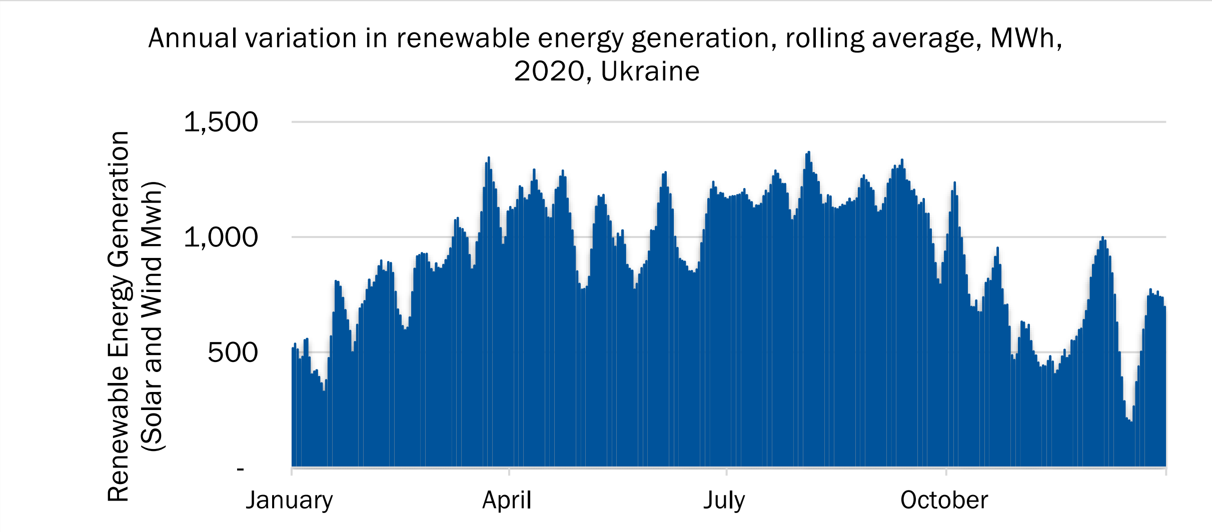
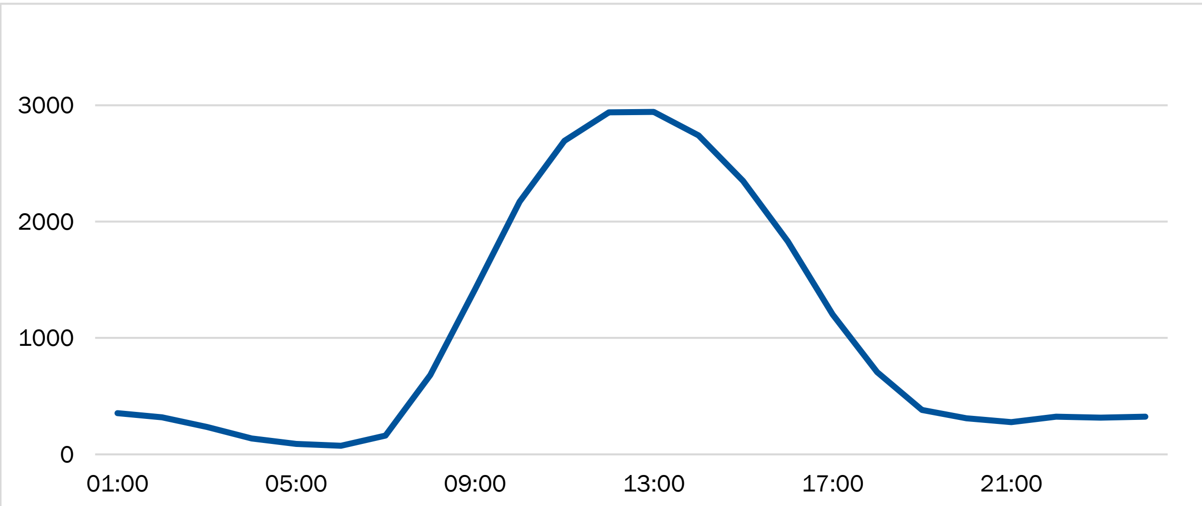


Figure 2: Daily variation in Renewable energy generation, MWh, Ukraine [7]



The extent to which intermittent renewable energy generation is a problem will vary depending on a wide range of factors. The total scale of intermittent renewable energy within a system, the mix of renewable energy sources employed, the typical demand profile, and contextual differences such as whether there are seasonal patterns to intermittent renewable energy generation will all influence how policy-makers address the challenge of intermittency.

However, in conducting reviews of relevant evaluations, EvD has identified five broader insights on supporting the integration of intermittent renewable energy.

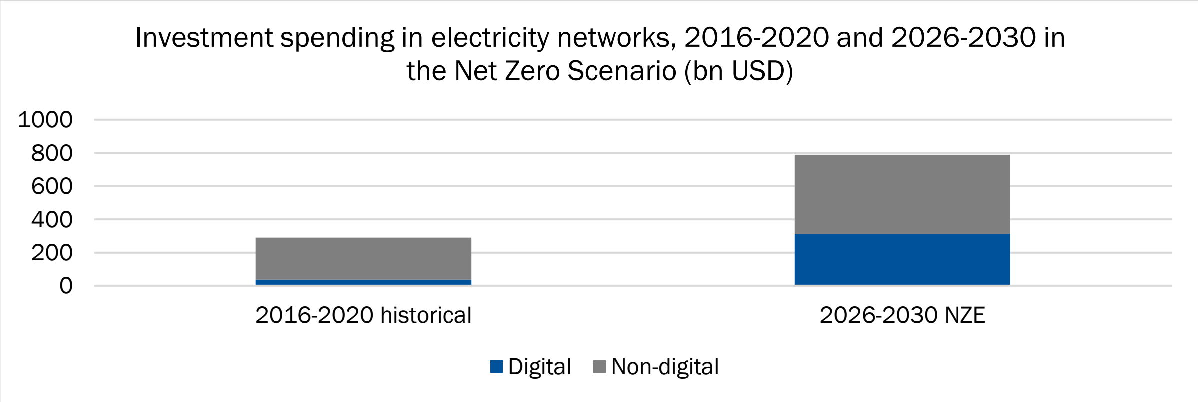
Insight 1:	**Scaling up renewable energy requires combining investments in energy generation and in grid infrastructure**
Insight 2:	**A cross-border approach is another systemic tool to support integration**
Insight 3:	**Harnessing the potential of smart grids to provide energy balancing and supporting integration**
Insight 4:	**Non-renewable energy investments can still support the integration of intermittent renewable energy**
Insight 5:	**Electrification is changing the transferability between different types of energy, which provides opportunities for intermittent renewable energy integration**
Insight 6:	**Energy storage opens up new opportunities for intermittent renewable energy integration**

Insight 1 Scaling up renewable energy requires combining investments in energy generation and grid infrastructure

A reoccurring theme within evaluations is steering investments towards integrating the delivery of renewable energy as well as financing primary renewable energy production[8]. For example, the AfDB Energy Sector Evaluation recommended that the Bank should "consider balancing its investments between power generation, and transmission and distribution"[9], whilst the ADB Energy Sector evaluation suggested the ADB should "increase support to address gaps in ADB energy operations in key areas, including…distribution network enhancement, and renewable energy integration"[10].

This finding from evaluation has been reinforced by forecasts of the investment requirements for electricity network infrastructure to support the green transition. Not only will investment levels have to increase significantly, but the type of investment will also evolve, as grids become smart and digital to accommodate intermittent renewable energy[11].

Figure 3: Investments into grid infrastructure will have to increase significantly[12]



Energy evaluations provide examples of the consequences when investments are unbalanced between renewable energy production and delivery via grid infrastructure. The Independent Evaluation Group (IEG) Evaluation of the World Bank Group's (WBG) Support for Electricity Supply from Renewable Energy Resources found that "in the Inner Mongolia Autonomous Region of the PRC…a relatively inflexible grid has resulted in a large-scale curtailment of low-cost wind energy"[13]. Similarly, the EvD evaluation of EBRD solar operations observed how growth of solar had stalled in Jordan over grid capacity constraints[14].

The sequencing of investments between power production and transmission delivery also matters. This was demonstrated by the EvD Validation of the EBRD Dariali Hydropower Plant project in Georgia (2020), which found that the "Plant was able to transmit only about half the electricity it could have generated due to the 44 months delay with the completion of the new 90km 550kV transmission line"[15]. There were also some cases where investments in delivery transmission infrastructure were undermined because there was no follow-on investment in power production, such as the IEG evaluation of the WBG Egypt Wind Power Development project which highlighted the "insufficient development of the wind power plants…[which] may result in the underutilisation of the transmission line built under this project"[16].

Conversely, investments in delivery transmission infrastructure can unlock growth. In five of the six countries selected as case studies for the EvD solar evaluation, the EBRD had made significant investments in upgrading national grids, with a clear relationship to subsequent renewable energy investments[17]. Similarly, an Independent Evaluation Department (IED) Validation of an Asian Development Bank (ADB) transmission project in India identified the importance of grid investments in stimulating renewable energy projects[18].

With insufficient grid infrastructure, there will be a clear ceiling on the penetration of intermittent renewable energy, as demonstrated by the examples of China and Jordan provided above. This can have implications for both environmental sustainability and energy security, through continuing to promote reliance upon foreign hydrocarbons. Inadequate integration of intermittent energy into grid infrastructure can also affect the reliability of energy supply.

Box 2: Rising to the challenge – investing in grid infrastructure

Whilst identifying the importance of investing in grid infrastructure, evaluations have also recognised that developing grid infrastructure can be challenging for a variety of reasons:

- **Engagement with state-owned entities:** As highlighted in the EvD solar evaluation, transmission infrastructure is routinely managed by state-owned entities, who often face legacy issues related to cash flow and corporate governance[19].
- **Technical complexity:** Developing transmission infrastructure can be more technically complex than both hydrocarbon and renewable power generation; as the IED Evaluation of the ADB's Energy Policy noted, "generation projects are generally more straightforward to implement as they are usually turn-key projects on government or private land"[20].
- **Public good:** Transmission infrastructure is a public good, with improvements in transmission infrastructure accruing to multiple different stakeholders (generators, distributors, and consumers) depending on market structure. This can lead to complex political economy for transmission projects in terms of how they are funded, given the range of actors who benefit.
- **Sub-standard performance:** There is some evidence from evaluation that grid infrastructure projects routinely underperform, for the reasons explained above. The Independent Development Evaluation (IDEV) evaluation of the African Development Bank's (AfDB) Assistance to the Energy Sector highlighted that energy projects were typically delayed by 34 months (nearly 3 years), in comparison with power generation projects that were delayed by less than two years[21]. Similarly, the IED Evaluation of the ADB's Energy Policy found that "renewable energy generation was the most successful, followed closely by conventional energy generation", whilst projects categorised as "Energy sector development and institutional reform" were rated as "less than successful"[22].

Insight 2 Interlinking energy systems across borders supports the integration of intermittent renewable energy

Evaluations have demonstrated that interlinking electricity transmission networks can encourage the development of new renewable resources, by smoothing out peaks in demand and energy supply. IDEV's cluster evaluation of the AfDB's support grid interconnection also showed that interconnected grids can support greater diversification of energy sources[23]. Supporting cross-border connections can create more challenging projects but can also support the development of more sustainable, secure, and affordable energy systems.

Box 4: The barriers to working cross-border

Cross-border projects are inherently complex projects, as successful electricity market integration requires not just cross-border infrastructure, but also institutional reform, political support, and, in some cases, additional investment in national-level transmission capacity.

An example is provided by the IED Evaluation of the ADB Georgia Cross-Border project, which found that "lack of institutional coordination, and geopolitics jeopardised efforts for regional electricity market integration". Even though "Georgia had expanded its transit and cross-border transmission capacity, actual regional power trade remains very seasonal, and uses less than 10% of available capacity"[24]. In this case, despite having the infrastructure, the energy systems in Georgia were not materially benefiting from the cross-border connections.

But success factors have been identified:

- **Strong political commitment:** The IED Synthesis of ADB Energy Sector Project Evaluations 2015-2019 highlighted "strong ownership by country champions" as key for cross-border grid connections[25]. Similarly, the IDEV evaluation of the AfDB's support to cross-border connections identified "sustained political commitment" as a success factor[26].
- **Complementarity** between power systems in terms of generation profile, and increasing the diversity of power generation, has also been identified as a success factor[27].

Insight 3 — Harnessing the potential of smart grids to provide energy balancing and supporting integration

Introducing new demand-side interventions such as smart meters and smart grids side, can alleviate pressure on other components of the energy system and support the integration of intermittent renewable energy. The IDEV Evaluation of the AfDB's assistance to the energy sector suggested that the AfDB roll out prepaid and smart-metering solutions, partly because of the consequences for the generation and transmission components of the energy system[28]. Similarly, the IED Working Paper providing guidance on how ADB can increase the penetration of variable renewable energy highlighted the role of smart grids as both an effective demand side and supply side intervention for integrating renewable energy. Conversely, EvD's 2018 Review of the EBRD Energy Sector Strategy 2014-2018 found that the EBRD's focus was limited to supply side factors and did not address operational activities on the demand side[29].

Insight 4 — Non-renewable energy investments can still support the integration of intermittent renewable energy

Multiple evaluations have emphasised the interplay between renewable energy and non-green energy. The EvD evaluation of the EBRD's solar investments noted the importance of modern-gas power plants in enabling the expansion of solar energy[30], whilst the IEG Evaluation of the WBG's Support to Renewable Energy highlighted the utility of dispatchable hydrocarbon power plants in developing green energy systems[31]. These evaluations recognise that in some specific contexts there may be a role for dispatchable hydrocarbon power plants, which can generate energy on demand, in providing balancing to intermittent renewable energy.

EvD's evaluation of the EBRD's solar investments used the case study of Uzbekistan as an example of how dispatchable hydrocarbon power plants can support renewable energy[32]. In Uzbekistan, the EBRD supported the development of a Low Carbon Pathway for the electricity sector, which provided a roadmap for reaching carbon-neutral electricity by 2050. This roadmap found that "efficient natural gas-fired capacity is essential…the country's gas resources will play a role in balancing the system should the installation of storage capacity not keep pace with intermittent renewables"[33]. The EBRD subsequently financed a modern gas power plant in Uzbekistan to support balancing, in tandem with providing funding to scale renewables.

This is not a blanket recommendation to support hydrocarbons. In the example described above, the EBRD took a comprehensive, long-term approach, which identified the relationship of gas power plants in low-carbon transition. This demonstrates there is not always a binary choice between green and non-green power sources, and 'non-green' sources of power can still have a role to play in in specific, limited contexts.

Insight 5 Electrification is providing opportunities for intermittent renewable energy integration

As noted in the IED Evaluation of the ADB's Energy Policy, going forward there will be more opportunities for convertibility between different types of energy[34]. This process will primarily be driven by the increasing electrification of different sectors, including transport, heat, and industry. Increasing electrification will drive demand for renewable energy generation, introduce new opportunities for energy storage, and put additional pressure on grid infrastructure.

Electrification brings opportunities for renewable energy generation, particularly mechanisms which enable productive usage of 'excess' renewable energy. The electrification of transport provides a clear example, with renewable energy generation in excess of current energy demand used to charge electric cars. This could help address the intermittency challenges associated with renewable energy, improve the marginal value of renewable electricity generated during periods of high supply and low demand, and increase the penetration capacity of renewable energy into the energy system.

However, electrification will also bring risks, most notably in the form of increased pressure on the national grid. IED Evaluation of the ADB's Energy Policy recognised that "greater demand for electric vehicles…will increase electricity demand, and, most importantly, place a significant load on distribution networks, which are currently unprepared to support such loads" [35]. Taking advantage of electrification will necessitate significant investments in grid capacity.

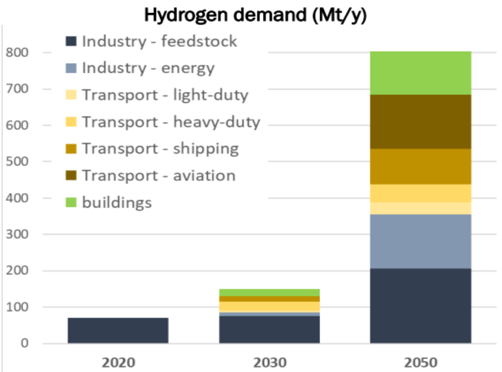
Energy storage opens up new opportunities for intermittent renewable energy integration

As highlighted by several evaluations, energy storage presents opportunities for the integration of intermittent renewable energy. Energy storage is still dominated by hydropower, but both thermal storage and battery storage are progressing towards commercialisation[36]. EvD's cluster evaluation of the EBRD's solar portfolio incorporated details from several ongoing technical cooperation assignments on the viability of different storage options and their importance to the long-term, sustainable development of the solar sector[37].

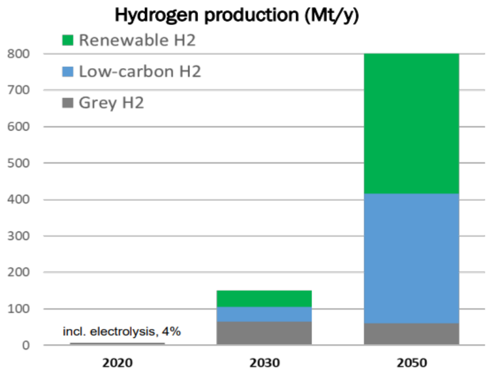
The arrival of hydrogen could have similar consequences. As noted during the EBRD's Board Information Session on Hydrogen, hydrogen has significant potential as a mechanism for energy storage, thereby addressing intermittency.

Box 3: Hydrogen as energy storage

"Green" hydrogen has significant potential as a vector for energy storage. Electricity generated from renewable energy sources is used to split water into hydrogen molecules, thereby creating an effective fuel for combustion. Hydrogen can be used as an energy source in a variety of different applications, including transport, heating and electricity generation. It could also be an effective "storage" unit for surplus electricity from intermittent renewable energy sources, addressing a significant constraint on the sector. The green hydrogen market is currently small but is expected to develop rapidly as the technology improves, with forecasts that the global hydrogen market will require US$ 3.7 trillion of investment by 2050[38].



Outlook for EU: 20-25% of total final energy demand (ca. 10% of global demand) by 2050



Technology mix: Low-carbon hydrogen and renewable hydrogen will coexist well into the 2050s

4 Building markets to promote green energy – getting the incentives right

The technical integration of intermittent renewable energy is one critical challenge in the green energy transition. A second fundamental building block is supporting the development of markets which promote and support sustainable renewable-energy investment. Evaluations have demonstrated multiple examples where markets and policy were not conducive towards long-term investment, often by providing misaligned incentives to private sector investors which do not correspond with long-term systemic health. This reflects the challenge of implementing a holistic approach towards energy systems, which has been noted by multiple evaluations including EvD's 2018 evaluation of the EBRD's Energy Sector Strategy 2014-2018[39].

This difficulty is compounded by the range of maturities in energy markets in the regions in which the Bank operates. The optimal market structure will change depending on the level of maturity, implying bespoke solutions for each market. Equally, policy instruments need to be conducive to long-term development, without risk of regulatory 'lock-in' which restricts market growth. EvD has identified several insights from evaluation on energy markets:

Insight 7: **Combining the mobilisation of private sector investment with systemic oversight**

Insight 8: **The rapid transformation of energy systems can generate risk and create misaligned incentives in static market structures and policy environments**

Insight 9: **Moving away from the security of price stability could support more flexible and resilient power systems.**

Insight 10: **As the profile of energy generation changes, the cost of capital will become a barrier to market growth.**

Insight 7 Combining the mobilisation of private sector investment with systemic oversight

The rationale for private sector involvement in the green energy transition is clear. Beyond increasing access to capital to bridge the financing deficit in addressing the climate emergency, the private sector can bring in dynamism, innovation, and expertise in support of the development of energy systems.

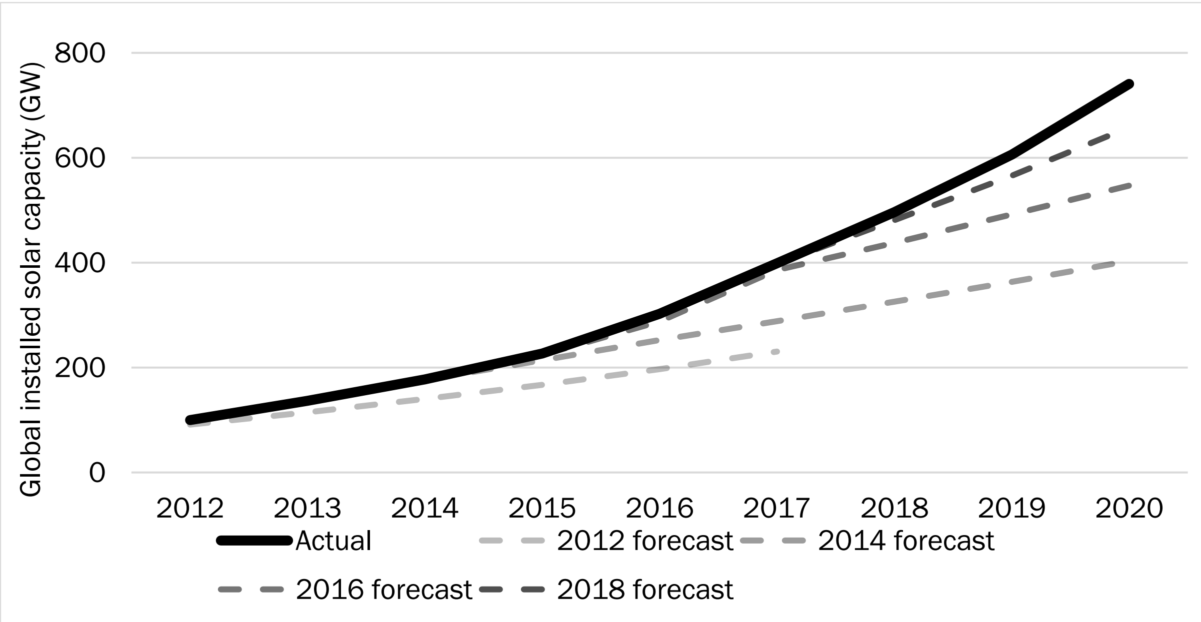
However, without an appropriate set of incentives and a clear long-term direction, there is a risk of adverse consequences from private sector investment. Multiple evaluations highlighted how short-term private sector led projects were not conducive towards long-term energy sector development. For example, an IED evaluation of the ADB's support to the Pakistan Energy Sector highlighted the risk of turning to the "private sector as a short-term solution… but without supporting long-term planning"[40]. Similarly, the EvD evaluation of the EBRD's Solar Investments as well as the EvD evaluation of the EBRD's Sustainable Infrastructure in Advanced Transition Countries provided case studies of Ukraine and Poland where skewed incentives led to private sector participation that was not sustainable[41].

For organisations supporting private sector involvement in energy systems, this means taking a systems-led rather than project-led approach. Operating on a project-by-project basis and viewing each project through the lens of a private sector developer increases the risk that wider systemic inefficiencies are ignored. This also means managing the complementarity between public grid investments and private generation investments, as highlighted in Insight 1.

Insight 8 The rapid transformation of energy systems can generate risk and create misaligned incentives in static market structures and policy environments

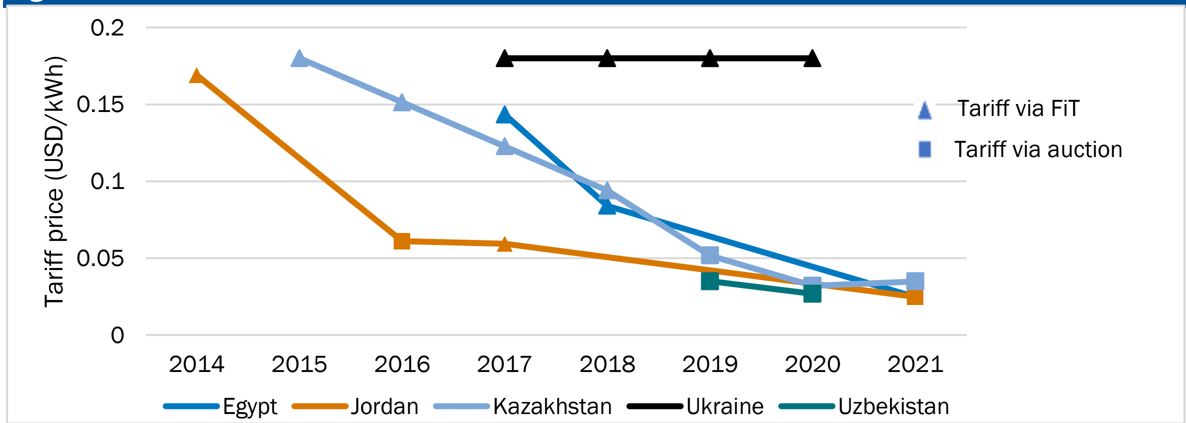
Dynamic and fast-evolving systems can rapidly generate large systemic risks. The EvD evaluation of the EBRD's investments in solar in Ukraine provided an example of how systemic risk can accumulate in dynamic systems, particularly with inflexible market structures[42]. This risk is compounded when realised performance exceeds forecasts, which has been a reoccurring trend in parts of the green energy transition.

Figure 4: Comparison of global installed solar capacity with IEA forecasts: Actual growth has exceeded forecasts - Even policymakers 'pricing in' growth have been left behind [43]



Ukraine provides an example of this mechanism in practice. Ukraine had set a fixed Feed-in-Tariff for solar energy, to incentivize development and to promote a low-carbon, secure energy-system. However, the decline in the cost of solar was much faster than the tariff schedule anticipated, which is demonstrated by a comparison of the prevailing tariff rate payable for solar in Ukraine with tariffs in other countries. Whilst there are a number of factors which could explain changes in the headline tariff price – differences in the policy environment, PPA length, cost of capital, and solar irradiation, for example – it is a reasonable assumption that tariff prices will follow the same direction across different countries as the underlying technology changes.

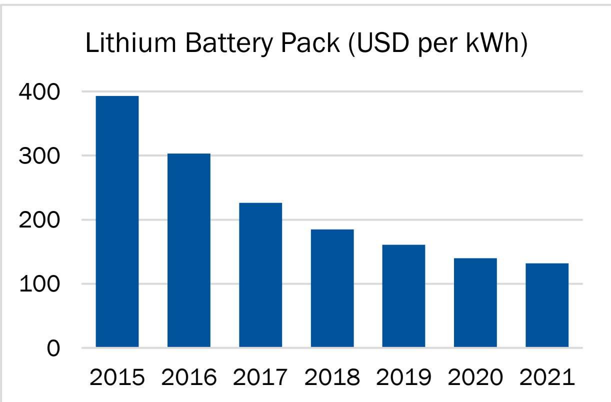
Figure 5: Tariff rates for solar in selected countries[44]

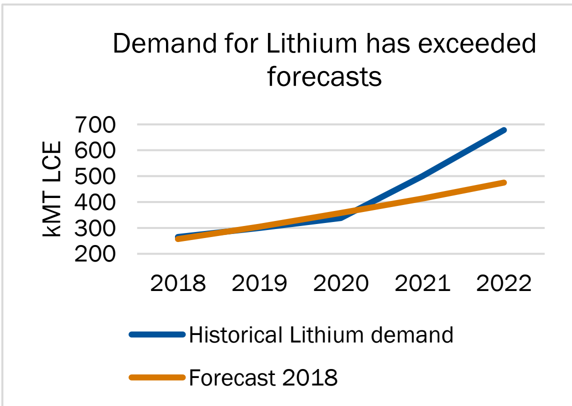


As a market outcome, the fixed tariff price within Ukraine had predictable consequences. The tariff attracted investors to the solar sector in Ukraine, particularly given the fall in the cost of solar panels. This led to very rapid growth in the sector; between YE 2017 and YE 2019, installed solar capacity in Ukraine rose by 494%, from 1.2 GW to 5.9 GW[45]. This level of market subsidy was not a sustainable solution for the Government of Ukraine, particularly when combined with the impact of the COVID-19 pandemic. Subsequently, a retrospective tariff cut was imposed in 2020, damaging investor confidence in the sector.

This situation is not unique to Ukraine. As the IEG Evaluation of the WBG's Support for Electricity Supply from Renewable Energy Resources highlighted, offtakers in China also faced financial difficulties in meeting FiT commitments after a rapid-scale up, a consequence of the FiT not adjusting at the same rate as the changing cost structure of the market[46]. Similar challenges

Figure 6: The market for lithium batteries has experienced a similar dynamic to solar panels, with a rapid fall in prices and demand exceeding forecasts





have been highlighted in EvD evaluations of EBRD support to renewable energy in Poland[47]. With the level of financing and the pace of technological change, there is also clear potential for similarly rapid shifts in market dynamics in other energy sub-sectors, including battery storage, hydrogen, and other forms of renewable energy[48].

Insight 9 In some cases, moving away from the security of price stability could support the development of more flexible and resilient power systems

The use of long-term Power-Purchase Agreements (PPAs), typically based on either FiTs or tariffs set through competitive auctions, has had a clear impact on the growth of the renewable energy sector. Their impact has been validated by many evaluations across different MDBs. Providing stable and predictable revenue via a fixed tariff has helped to attract private sector investors into renewable energy.

However, the tariff cost of renewables through PPAs is not a fair reflection of their competitiveness vis-à-vis other energy sources. As a pricing mechanism, it also cannot provide value for different energy market services, such as balancing, storage, or base-load services. Despite the success of PPAs in promoting the development of renewable energy, in more mature, developed markets there is clear rationale for starting to pivot to more sophisticated pricing structures, which incentivize the development of ancillary services. As the IEG's report for the WBG on Emerging Opportunities and Challenges in Renewable Energy noted, "as the penetration of VRE [Variable Renewable Energy] increases in power systems, it may be necessary to reconfigure electricity markets to provide for price discovery"[49]. In effect, this means trying to develop markets that enable price-based mechanisms for the most efficient mix of intermittent renewable energy, storage, balancing services, and baseload energy generation. More flexible pricing can create market incentives for an appropriate balance of energy sources to support the growth of intermittent renewable energy.

Box 4: Curtailment – moving from a risk to a market opportunity

For renewable energy projects, curtailment is a risk. Curtailment is the process of reducing power generation in order to lessen the stress on the grid, during periods of high-power generation and low demand. Curtailment is perceived as a risk from the power producer perspective if unused energy is not paid for, affecting revenue for the power producer. To mitigate against that risk, IFIs, including the EBRD, have typically supported the development of power-purchase-agreements with guaranteed off-take for renewable energy producers, and priority dispatch of renewable energy to the national grid. This provides for revenue stability for renewable energy investors.

However, curtailment has benefits to other actors within energy systems. A presentation at European Energy Evaluation Conference 2022 highlighted the significant systemic financial benefits by introducing a small degree of flexibility into the dispatch of intermittent renewable energy; analysis of the French power system demonstrated that providing off-takers with the capacity to curtail renewable power generation by an average of 0.06% would reduce capex expenditure on grid infrastructure by 30%.

In more mature markets, it is possible to shape market structures such that curtailment can become the optimal outcome for all stakeholders. Reimbursement of renewable energy generators for minor curtailment can lead to significant cost savings for grid operators, such that they can agree to reimburse generators for curtailment. Introducing a small amount of flexibility at a relatively marginal cost has a major impact on other parts of the energy system. However, this is dependent upon having the right market structures in place which enable curtailment as a market service rather than as a cost borne entirely by the power producer.

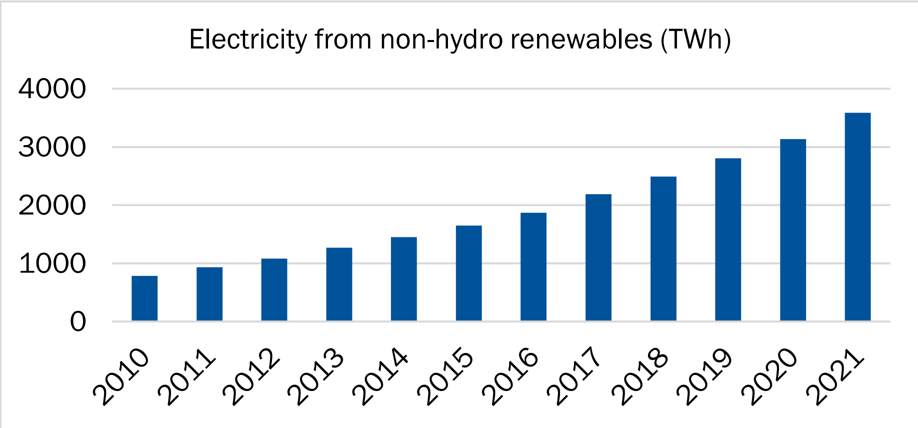
The EBRD's experience in the Polish wind energy sector provides some insights into the effect that more flexible pricing structures can have. As demonstrated in EvD's evaluation of the EBRD's Energy Sector Strategy, after significant support to Polish wind between 2014 and 2016, the introduction of an auction scheme that incentivised other sources of power was introduced in 2016, which led to the Bank temporarily withdrawing from the sector[50]. However, a new innovative and flexible auction scheme caused investment to resume in 2019[51], with the subsequent introduction of Contracts for Difference (CfDs) further attracting investment[52].

CfDs can act as a mid-way solution to maintain revenue stability for renewable energy generators whilst enabling participation in more sophisticated energy markets, as documented by recent project approval documents for wind projects in Poland financed by the EBRD[53]. Under CfDs, renewable energy producers receive a subsidy when their agreed tariff price is above the prevailing wholesale energy market price and pay a subsidy when the tariff price is below. The value of CfDs is that they provide investors with a predictable and stable revenue base, whilst also supporting integration with liberalised energy markets that incentivize ancillary services. CfDs can also support off-takers during periods of high energy prices, such as those caused by the Russian War on Ukraine[54].

Insight 10 As the profile of energy generation changes, the cost of capital will become a barrier to market growth

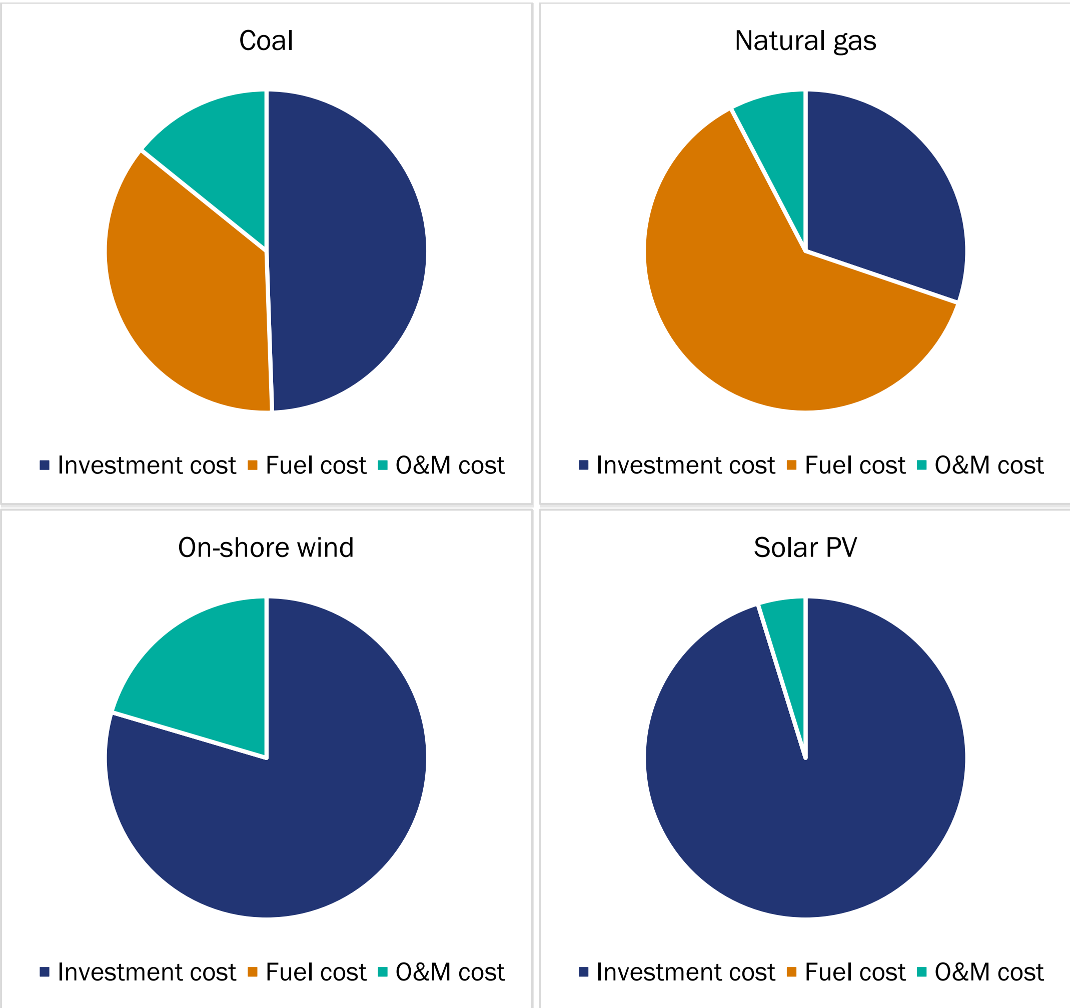
Renewable energy generation has increased rapidly, with energy generation from non-hydro renewables climbing by over 450% since 2010[55]. This represents a fundamental shift in how energy is generated, which implies a different set of tools for institutions aiming to address barriers towards investment in energy systems.

Figure 7: Electricity generation from non-hydro renewables has grown rapidly



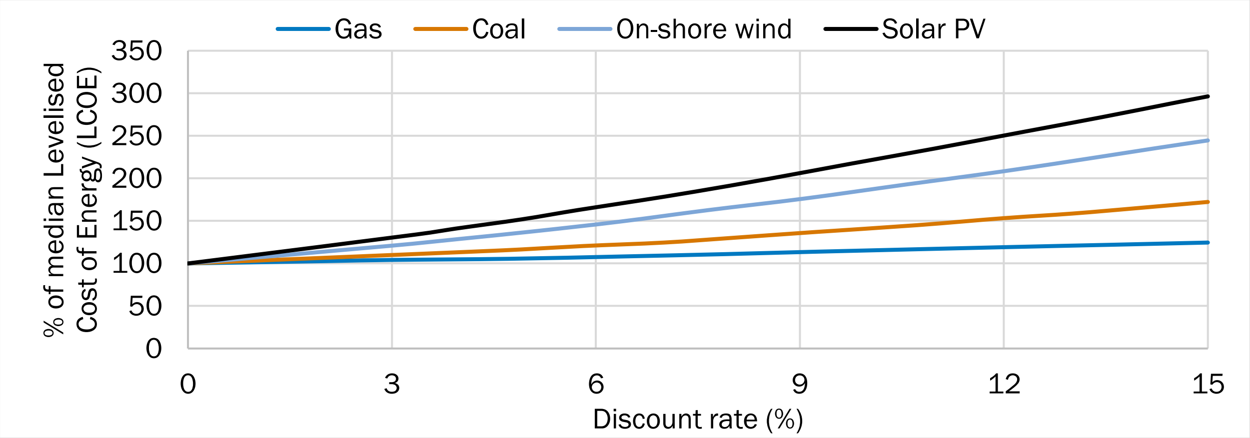
However, the cost profile of renewable energy generation is significantly different when compared to traditional power generation. The cost of renewable energy is derived from the up-front cost of investment. For hydrocarbon electricity generation such as coal or gas, the key cost drivers are the ongoing costs of fuel and operations and maintenance.

Figure 8: Relative contribution of different cost areas to levelised cost of electricity[56]



This means that the cost of capital is a greater cost driver for renewable energy than it is for traditional hydrocarbon power generation. Modelling the cost of energy as a function of the discount rate demonstrates this mechanism. Raising the discount rate from 0% to 15% increases the lifetime levelised cost of energy produced by a gas power-plant by 24%; in comparison, increasing the discount rate from 0% to 15% increases the cost of solar energy by 296%.

Figure 9: Levelised Cost of Energy as a Function of the Discount Rate[57]



Unfortunately, as illustrated within EvD's cluster evaluation of the EBRD's solar portfolio, commercial banks are often not able to provide affordable project-based finance to renewable energy projects[58]. Case studies examining solar investments in Jordan and Ukraine highlighted that local banks faced significant regulatory restrictions on project-based lending for renewables, which raised the cost of capital to prohibitive levels.

In addition to providing financing directly for renewable energy projects, the EvD cluster evaluation of the EBRD's solar portfolio recommended the Bank address the constraints on commercial financing[59]. Intervening in this section of the market could have an outsized impact on the growth of renewable energy, and through doing so promote energy affordability and sustainability. During a macro-economic environment where interest rates are rising globally, providing support to financial institutions in addressing regulatory barriers to investment in renewable energy is a key tool for promoting the green transition.

However, this does not necessarily mean that there is a role for concessional financing to reduce the interest rate, particularly for mature renewable technologies. Using concessional finance for a technology such as solar PV, where in the right circumstances the business model has been validated, is in effect subsidising an inefficient market structure rather than an innovative and risky technology. This has questionable utility, can lead to moral hazard problems, and will in many cases represent an inefficient use of limited concessional finance resources.

5 Conclusion

The energy sector is in the midst of major transformation. The climate crisis is necessitating a rapid restructuring of global energy systems. Compounding that dynamic is the impact of the Russian War of Aggression on Ukraine, which has impacted upon energy markets worldwide, caused energy prices to rise dramatically, and led to an increased emphasis on energy security.

Insights from evaluation demonstrate the importance of taking a holistic approach to energy systems, which account for the technical integration of intermittent renewable energy. To support the development of secure, affordable, and sustainable energy systems, it is critical that policy-makers take a systemic approach, which addresses the intermittency, and is responsive to the dynamic and evolving structures of energy markets.

[1] Sources that were used in the development of this paper include the African Development Bank (AFD), Asian Development Bank (ADB), European Investment Bank (EIB), the World Bank, BII (formerly CDC), KfW (the German Development Bank), the Inter-American Development Bank (IADB), and the FMO (the Dutch Entrepreneurial Development Bank).
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