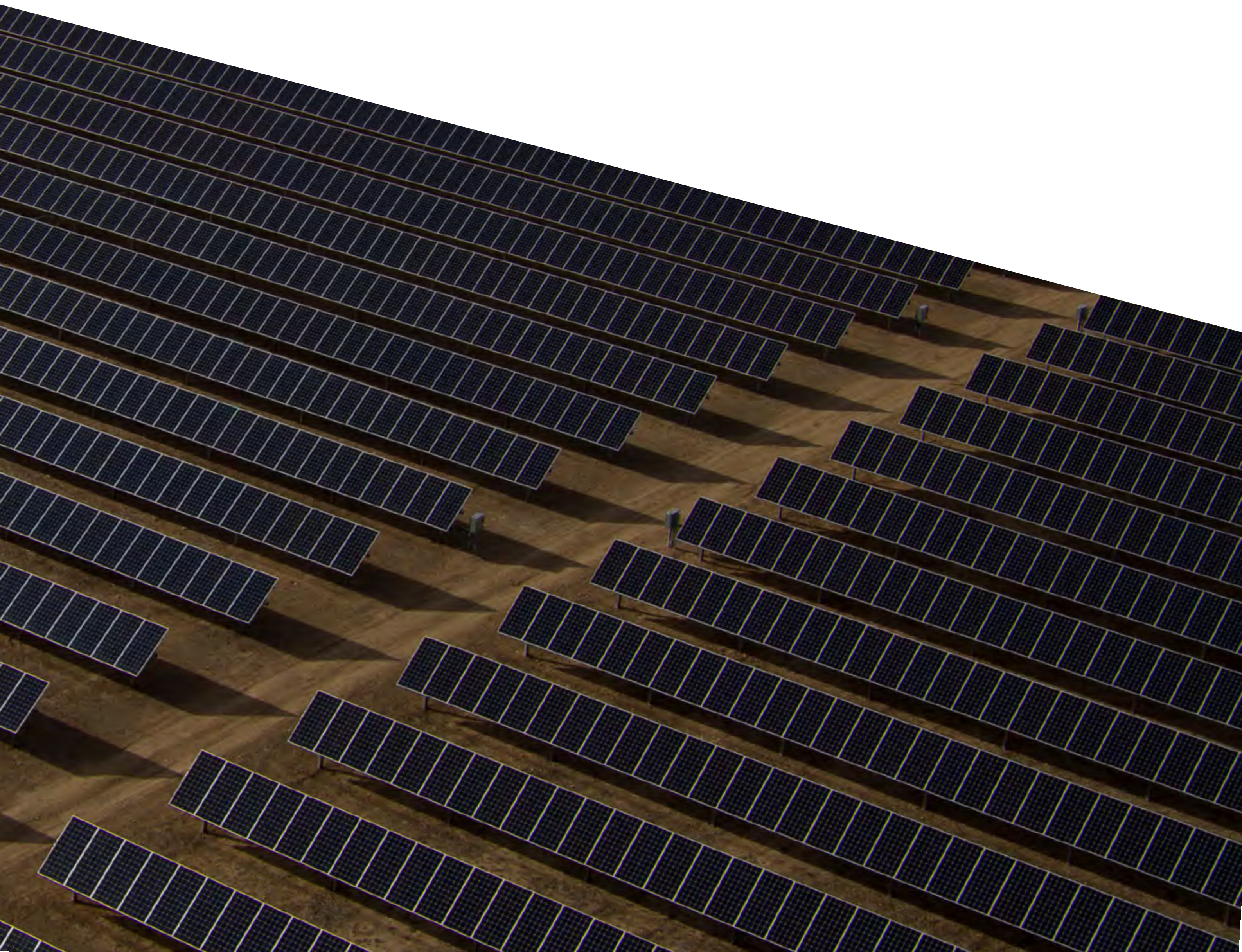
Agora Energiewende

A WORD ON

LOW COST RENEWABLES

The Renewables Breakthrough:
How to Secure Low Cost Renewables



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IMPRINT

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The Renewables Breakthrough:
How to Secure Low Cost Renewables

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WHAT YOU WILL LEARN

Renewable energy has rapidly emerged as the lowest cost source of new power generation in most electricity markets around the world.

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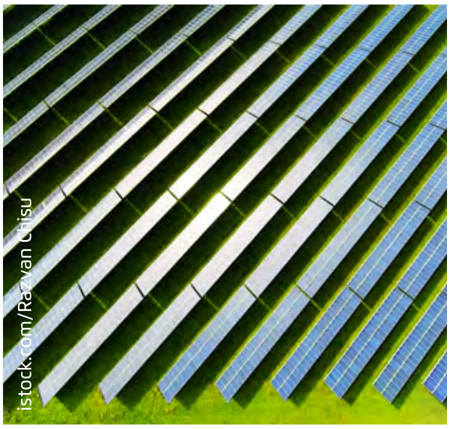
Recent renewable energy prices are shaking up the global energy landscape: as renewable energy technologies become **the lowest cost source for new power generation,** governments and utilities around the world are responding by purchasing more, triggering a powerful feedback loop as economies of scale continue to grow, supply chains mature, and technologies continue to improve. Taken together, these developments are in the process of turning renewables' recent cost advantage into a permanent competitive edge.



Recent breakthrough prices for renewable energy are the product of a wide range of different contractual, regulatory, market, and resource-related factors:

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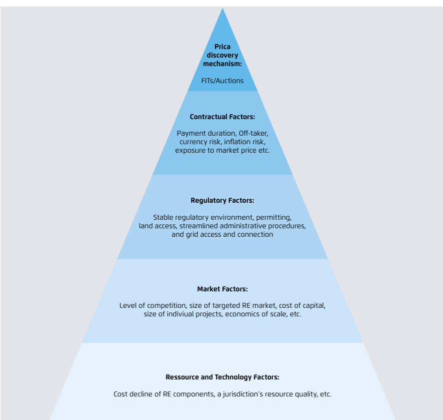
Due to a powerful combination of political and market factors, including abundant renewable energy resources, some countries like Mexico, Chile and the United Arab Emirates have recently achieved record-low prices around 0.02 USD/kWh for large-scale wind and solar projects. This report organizes these various elements into a "pyramid" of contractual, regulatory, market, and resource-related factors, each component of which plays a critical role in reducing overall renewable energy project costs.



While policy makers cannot control resource quality, many crucial policy and regulatory elements are within their control and can be designed to support the fast and lasting growth of renewable energy.

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For small island states, land-locked regions, northern climates, as well as cloudier regions of the globe, achieving the lowest cost renewables seen in markets like Mexico, Saudi Arabia, or the United Arab Emirates may never be possible. **Resource and market conditions may simply prevent generating electricity at those breakthrough costs.** The challenge for each jurisdiction is therefore to make the best use of the available policy and regulatory elements to support the achievement of the lowest cost renewables that are possible under local conditions. Policymakers should strive to make the best use of existing resource and market conditions, while calibrating their policy, regulatory, and contract designs to reduce key investment risks.

Achieving the lowest possible per-kWh cost is only part of the equation: in some cases, governments have introduced policies that slightly increase project costs in order to deliver on other policy priorities.

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There are many policy objectives that may justify paying slightly higher prices: if electricity supply is scarce, there may be a premium on getting new generation built quickly, which may out-weigh policymakers' and regulators' traditional focus on cost. Similarly, policymakers may wish to ensure that most or all of the contracted capacity actually gets built rather than seeing a large number of bidders' proposals collapse due to under-bidding. Also, other jurisdictions may wish to encourage more local manufacturing, local supply chain development, or local community investment, despite the fact that such elements are likely to be reflected in a higher per-kWh cost.


fotolia.de/Ingo Bartussek

As such, **there are a number of trade-offs inherent in the quest to achieve the lowest cost renewables.** Policymakers may choose to prioritize these or other aspects, recognizing that establishing a long-term energy transition strategy may involve, even necessitate, the presence of a dynamic tension between different policy objectives.

Qualified workforce and specialized contractors are not only a pre-requisite to realize renewable energy projects on time and at cost. They are also the result of a well implemented strategy for building renewable energies.

CONTENT

Introduction

Renewable energy technologies have undergone dramatic cost reductions in recent years, making them broadly cost-competitive with both fossil fuel and nuclear sources in markets around the world. In the process, renewables have redefined the global energy landscape: global investment flows increasingly favor renewable energy technologies, and the continued gains from economies of scale and technological improvement are poised to turn this relatively recent cost advantage into a permanent competitive edge.

From an unsubsidized cost of approximately 76 USD/watt in 1976, solar photovoltaic (PV) modules have declined in price to below $0.50 USD/watt in 2017, with the total installed costs for ground-mounted PV systems having recently fallen below 1 USD/watt.[1] This rapid cost reduction is evidenced in recent auction rounds that have taken place around the world.

In recent months, the reported winning bid in a solar PV auction in Saudi Arabia was 1.79 USD cents/kWh,[2] and similar prices have been achieved in the United Arab Emirates[3] (2.42 USD cents/kWh), Chile[4] (2.91 USD cents/kWh), and Mexico[5] (3.17 USD cents/kWh median price for all bids).

In the wind power sector, similar cost declines have been observed. At the windiest locations, the levelized cost of wind power generation in the U.S. averaged around 55 USD cents/kWh in 1980. By 2000, the levelized cost of wind power had declined by over 90 % to approximately 6 USD cents/kWh. Furthermore, recent technological trends are already unlocking further reductions.[6] In a number of recent auctions in Peru, and Morocco, onshore wind auctions have yielded results between 2.7 USD cents/kWh and 3.4 USD cents/kWh.[7] The Canadian province of Alberta recent December 2017 auction for onshore wind power resulted at 2.88 USD cents/kWh[8], while the November 2017 auction in Mexico saw a winning onshore wind bid of 1.77 USD cents/kWh.[9]

Despite coming relatively late to the party, offshore wind power is experiencing an equally remarkable evolution: the first offshore wind auctions in the North Sea in 2010 yielded costs of just over 160 EUR/MWh; more recent tenders have yielded prices in the range of 60 EUR/MWh, representing a remarkable 60 % cost decline in just under seven years. As larger turbine models come online and offshore operations and maintenance (O&M) teams grow in scale and sophistication, further cost reductions are expected.

These remarkable price reductions are an unmistakable sign that electricity systems around the world are poised for rapid change as renewable energy technologies, and in particular solar and wind power, become the default least-cost options for new electricity supply. While the media, analysts, and regulators marvel at the rapid cost declines that have taken place in recent years, less attention has been devoted to understanding the conditions that have enabled such low cost bids.

This paper seeks to provide an analysis of how these historically low costs (reflected primarily but not exclusively through bids in recent auctions) are

1 Roselund (2017)

2 Dipaola M. (2017a)

3 Dezem, M. (2017)

4 López, B. (2017)

5 American Wind Energy Association (2017)

6 Dipaola, M. (2017b)

7 See Agora Energiewende (2017)

8 https://www.nationalobserver.com/2017/12/14/news/alberta-blows-past-competition-claim-cheapest-wind-energy-rate

9 http://www.renewableenergymexico.com/mexicos-third-long-term-electricity-auction-the-results-and-the-comparison/

occurring, and what underlying conditions have made them possible. As such, this paper has been written to support policy makers in designing policy environments to enable low cost renewables in their jurisdictions.

Prices of renewables projects do not only reflect renewable energy technology costs; a host of other behavioral, institutional, regulatory, and strategic factors are always at play:

Uncertainty about actual project realization
Many of these historically low auction bid results have occurred in the last 12–18 months, which means that it remains unclear whether many of these projects will in fact be built at these prices and/or in line with agreed construction schedules.

There are clearly positive examples, such as a recent pair of wind projects in Chile, which achieved financial close after remarkably low auction results.[10] Another example is the 2016 PV tender in Dubai, with a winning bid of 2.99 USD cents/kWh. Here, 200 MW have recently come online and the remaining 600 MW are under construction.[11]

Still, uncertainty remains over a number of recent tenders. Despite the headline-grabbing numbers, it remains unclear whether the most recent bid prices will in fact result in projects being built, or whether winning bidders will be given the opportunity to re-negotiate for higher prices or later completion times. Indeed, such bids can only be understood as a robust indicator of future trends if the projects actually reach completion.

Pricing in future technology cost decreases
It is also important to underscore that the price bids in recent auctions are ultimately the prices that projects will receive once they begin commercial operation, which is often 12–24 months in the future for solar projects, and as much as 48–60 months in the future for offshore wind projects. Many project developers have placed their bids based on the expectation that further cost reductions will take place in the coming months and years. This is clearly one factor contributing to the impression that recent bid prices seem to be below the commercial break-even – indeed, if built today, many projects would incur losses. As such, recent breakthrough RE prices arguably reflect future, rather than current, market prices.

Another important factor is that many bids are based on the assumption that the interest rates used to finance the projects will remain broadly the same. Any significant changes to interest rates could render some projects unprofitable, or force an upward revision to contract prices.[12] This example underscores just how many different factors are at play in giving rise to the recent breakthrough prices we have seen.

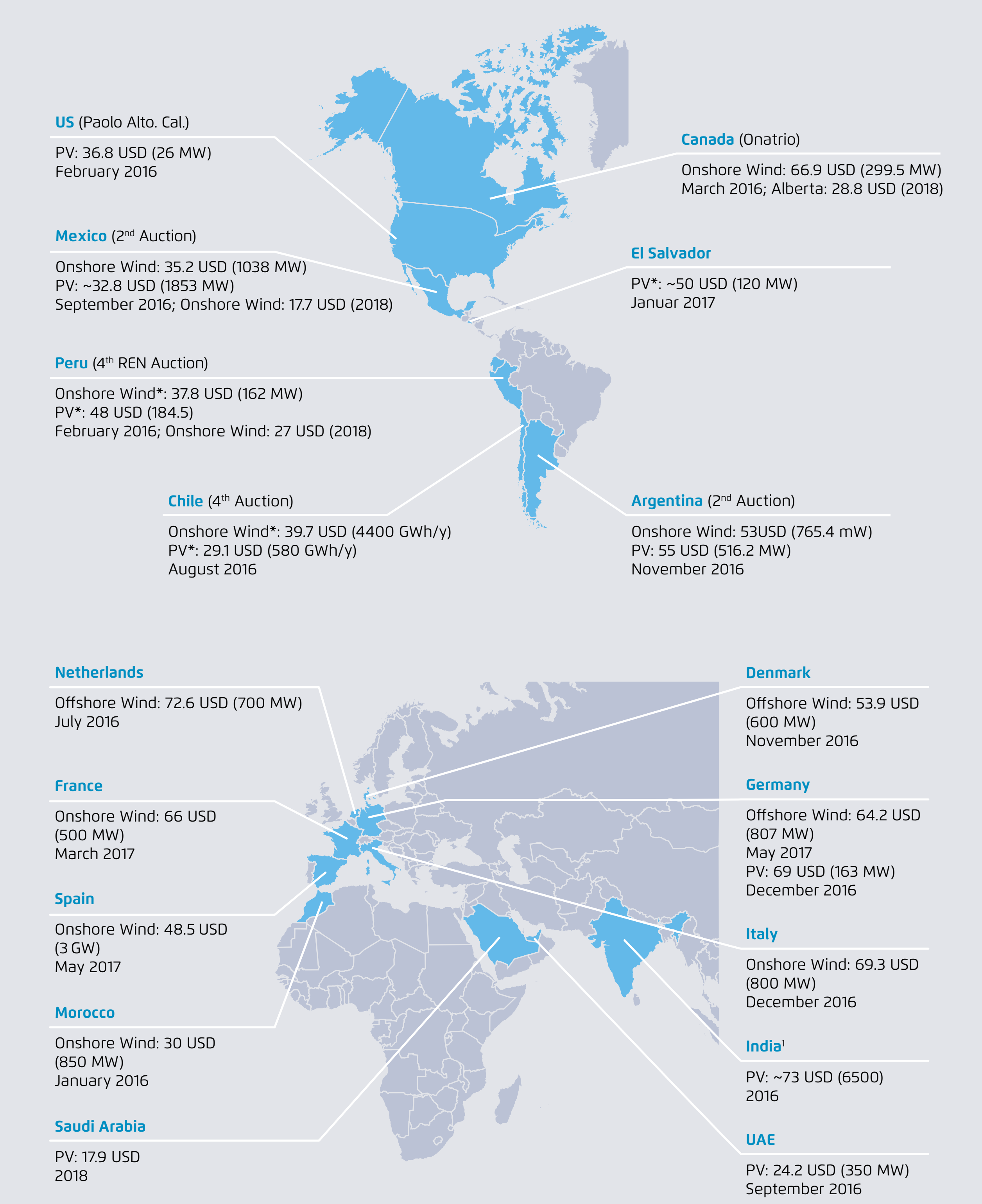
Bidding below actual costs
Finally, it is important not to underestimate the role of "market exuberance" in driving these historically low bid prices and to assess its potential impacts on project realization rates. Many bidders, particularly in new markets, often wish to enter the market for strategic reasons, hoping to gain a foothold and to begin building a local presence. This may justify bidding below one's own real cost of generation in the first or second auction round, simply in order to gain an all-important foothold, and to be better positioned for subsequent auctions. In other cases, getting into the market early may be seen to be necessary in order to comply with the anticipation of gradually increasing local content requirements in the future. Indeed, many of the winning bids received in renewable energy auctions around the world today would,

10 http://mainstreamrp.com/mainstreams-chilean-jv-obtains-us410m-in-project-finance-for-two-wind-farms/

11 http://taiyangnews.info/markets/200-mw-connected-to-grid-in-dubai/

12 https://www.powerengineeringint.com/articles/2018/02/iberdrola-chief-says-global-renewable-sector-facing-enron-style-endgame.html

Recent auction results for onshore wind and utility-scale photovoltaic projects per MWh Figure 1



Dipaola (2017), Dezem (2017), Fortum (2016), Lopez (2017), Agora Energiewende (2017), National Observer (2018), Renewables Mexico (2018) if constructed on schedule based on current technology costs, result in extremely low or even negative profitability, resulting in the so-called "winner's curse."

In addition to these many factors, it is critical to recognize that all of the recent record-breaking renewable energy prices have been enabled in part by historically low interest rates and the aggressive search for yield taking place among investors worldwide. If interest rates were to increase significantly in the months or years ahead, many of the recent bids in countries around the world would likely become untenable, setting off a cascade of renegotiations across the industry that could prove costly both for regulators as well as for rate payers, and lead to prolonged delays in project development.

Figure 1 above provides an overview of some of the most recent auction results worldwide.

Part 1: Understanding the Enabling Environment

No renewable energy support policy operates in a vacuum. Its success depends on the existence of an enabling environment of contractual, regulatory and market factors. The choice of procurement instrument (auction, feed-in tariffs, etc.) is frequently identified as the driving factor in bringing about low-cost renewables.[13] However, this assumption belies a more complex reality, one in which a wide range of policy, regulatory, and other factors play an important role. In the search for a simple narrative, many commentators have often overlooked such aspects.

In this regard, the choice between feed-in tariffs (FITs) and auctions can be thought of as the tip of the iceberg, the first and most visible feature of the renewable energy policy landscape (see Figure 2).

13 IRENA (2015, 2017), World Bank (2014), BNEF (2017), (IEA 2017)

However, the various policy and regulatory elements that lie below the surface can play a decisive role as well, where we can distinguish between three key factors:

Resource and technology related factors critically affect the project cost (Levelised Cost of Electricity, LCOE) of RES projects. They refer to the jurisdiction-specific factors such as the quality of the renewable energy resources as well as the broader role of technological cost reductions world-wide. Although renewable energy technology costs can differ significantly by region based on the proximity to where the components are manufactured as well

14 The off-taker is the buyer of the electricity. In most jurisdictions, this is the utility responsible for signing a contract, or power purchase agreement (PPA), with the renewable energy project developer.

	Description
1. Contractual factors	This factor refers specifically to the wide range of contract-related risks that investors and legal advisors look at to ensure that the contract is bankable, including payment duration, the creditworthiness of the off-taker,[14] the provisions in the contract dealing with currency risk, the clauses protecting against unexpectedly high inflation at any point over the contract period, the level of exposure to market prices (if any), etc.
2. Regulatory factors	This factor refers to a jurisdiction's overall regulatory environment, including the perceived stability of the regulatory regime, the predictability of certain key processes such as obtaining permits and securing land access, as well as the whole process governing grid access, including cost sharing between grid operators and project developers.
3. Market factors	This factor refers to the market, e.g. the size of the market (how much capacity is scheduled to be built, both in the near- and long-term), the level of competition, the overall project sizes, the broader macro-economic environment (interest rates, inflation, etc.) as well as the design of the overall electricity market in which the renewable energy projects are being developed.

INSIGHT: The downsides of the scramble to achieve lowest possible RE costs

Least cost deployment of electricity generation is one of the primary energy policy objectives in jurisdictions around the globe. However, solely focusing on low-cost renewables often competes with other important policy objectives, including the potential negative impacts on public acceptance, increasing market concentration, lack of community and local investor engagement, as well as the risk of low project realization rates.

Security of supply:
If electricity is in short supply and outages are occurring or anticipated in the near future, policymakers and regulators may prioritize getting new generation built over achieving the lowest possible price. In some contexts, security of supply may simply be more important.

High project realization rates:
A number of earlier auctions in certain countries resulted in a fairly high share of project failures, with proposals collapsing before reaching the construction phase. Policymakers may therefore prioritize a high success rate over securing the lowest possible cost, particularly if achieving the lowest cost in auction rounds is found to be associated with a higher rate of project failure.

Including local communities and small-scale actors:
Many recent international auctions have been dominated by large developers, including in some cases state-backed entities. Such large actors often have cheaper access to capital and have greater ease accessing larger volumes of it, enabling them to unlock greater economies of scale than smaller actors. However, allocating the majority of the available renewable energy capacity to a few international consortia can effectively shut out local companies and investors, and increase citizen opposition to the proposed projects.

As a result, some jurisdictions have been designing auctions to enable local and community-led projects. Example design features include easing pre-qualification criteria (Germany); introducing minimum quotas for the share of contracted capacity that goes to locally owned projects (South Africa); and creating separate procurement mechanisms specifically for community-owned projects (Nova Scotia in Canada).

Smoother grid and system integration; reduced grid expansion costs:
Especially in smaller markets, it can be easier and cheaper for the grid operator (or the utility) to handle several smaller scale projects rather than one large project from the perspective of grid and system integration.

National manufacturing and local content requirements:
Many countries have introduced local content requirements on renewable energy project developers in order to generate greater local economic benefits (including job creation and industrial development). However, sourcing the hardware nationally frequently increases the costs of renewable energy projects.

Portfolio diversity and support for emerging RE technologies:
Focusing on only one or two least-cost technologies can have negative effects on system integration. For example, a pure focus on onshore wind energy may make RE costlier to integrate in the system and less reliable than a diversified portfolio featuring different generation sources. Having a variety of renewable

energy power generation technologies with different generation profiles can often help balance each other out, providing important benefits for system stability and reliability. Therefore, many policymakers have opted for supporting a large basket of renewable energy technologies to assure that some degree of portfolio diversity is achieved.

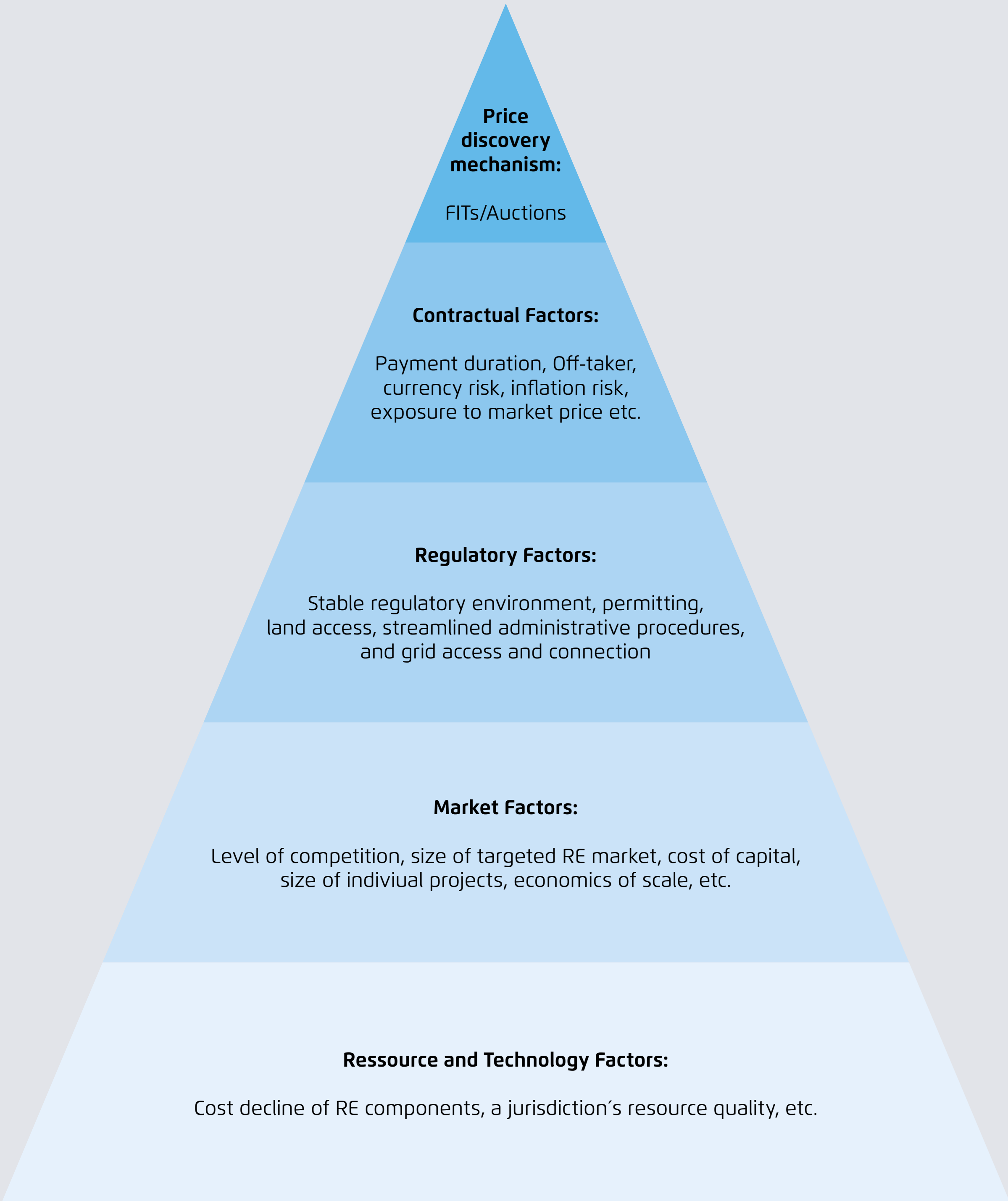
As highlighted here, there are a number of trade-offs inherent in the quest to achieve the lowest cost renewables. In some cases, policymakers will need to accept that cost considerations will occasionally need to be balanced against other policy objectives.

as based on the cost of labour, most of these factors are outside of individual governments' or auctioning agencies' ability to control.

Since policymakers have comparatively little control over resource and technology factors, these factors are not covered at length in this report. Instead, the focus lies on those *three factors* that policymakers can control, i. e. *contractual and regulatory* factors and to a certain extent *market factors*. These can be understood as the *"building blocks"* of an appropriate enabling environment for renewable energy technologies.

The Enabling Environment Pyramid

Figure 2



Couture and Jacobs (2018)

Part 2: The Building Blocks

2.1 Market Factors

This section covers the five most crucial building blocks grouped under Market Factors:

1. **Market size**
2. **Project size**
3. **Cost of capital**
4. **Presence of a qualified workforce**
5. **Presence of key supporting infrastructure**

Market size

Key insight: A large renewable energy market helps to reduce the overall costs of renewable energy projects by enabling greater economies of scale and fostering more competition.

Larger markets enable greater economies of scale, more competition for labor and parts, and can help support local manufacturing, all of which can help reduce the costs of each individual renewable energy project. As a result, jurisdictions with large renewable energy (RE) markets typically succeed in securing lower cost RE projects than smaller jurisdictions. In addition, smaller markets, most notably islands, typically face longer delays for importing replacement parts, which can further increase project costs.

Policy makers can support the creation of a larger renewable energy market through:
→ the adoption of large, more ambitious renewable energy targets;
→ cooperation with neighboring countries to allow larger individual projects to be connected to the grid (e.g. by enabling larger balancing areas, larger regional transmission areas);
→ harmonizing regional policies and planning; and
→ lowering barriers to investment, to increase the number of market participants.

Project size

Key insight: Large RE projects often benefit from numerous economies of scale that can help reduce the overall cost of electricity.

Project size can play an important role in driving down renewable energy costs. A recent solar PV auction in Turkey, for instance, resulted in a single consortium winning the entire allocated capacity for the auction of 1,000 MW.[15] Similarly, a recent solar PV auction in Dubai resulted in a contract being awarded for 1,170 MW of installed capacity at a final auction price of 2.4 USD cents/kWh.[16]

The size of winning bids continues to increase: until approximately 2014, it was extremely rare to see either wind or solar projects larger than 200 MW being built. But as the renewable energy industry has increasingly shifted toward newly industrialized countries such as China, Brazil, and Mexico, and as the renewables industry itself has grown in both size and sophistication, project sizes have continued to increase. However, as pointed out in the Insight box above, the quest for ever-larger projects and ever-lower prices can entail a number of important trade-offs, many of which have not yet been properly assessed and evaluated.

Figure 3 shows the trend of economies of scale for wind power for projects launched in the U.S. over the course of 2016.

15 Tsagas (2017), Bhambhani (2017).

16 O'Brian (2017)

Cost of capital

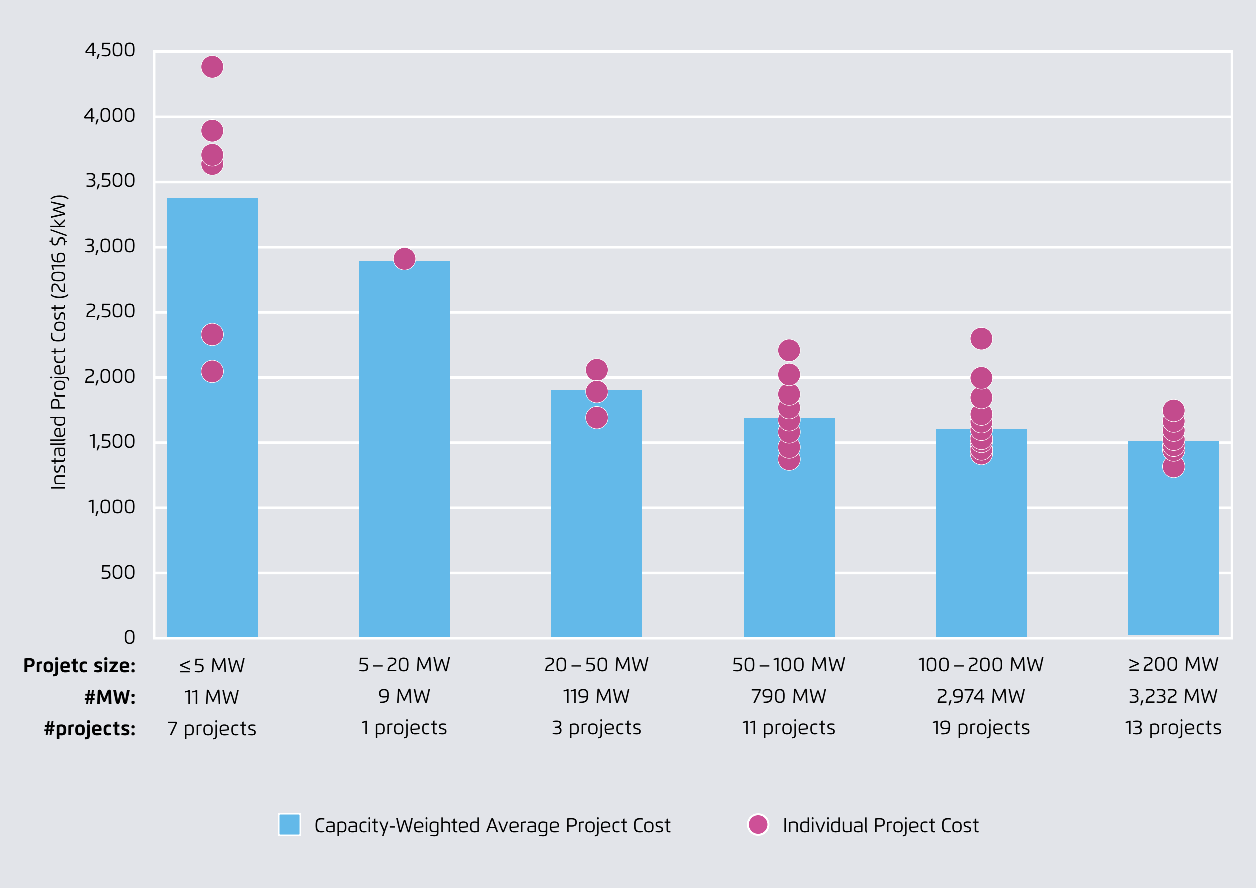
Key insight: Wind and PV have high upfront investment costs, which make them very sensitive to the cost of capital. To achieve low cost of capital, a stable and predictable regulatory environment is essential.

Most of the costs associated with a wind or solar PV project are locked in at the outset (e. g. for buying the necessary equipment). Accordingly, project costs are heavily impacted by the average interest rate used to finance the project. A higher average interest rate will mean that the LCOE of a project will be higher, as the revenues from selling electricity will need to cover not only the project's high fixed costs, but also the higher interest rates used to finance those costs. This is one reason why having access to cheap capital is one of the most critical factors for bringing down the cost of renewable electricity[17]

Especially in nascent markets, local and international banks might still be reluctant to finance renewable energy projects or ask for relatively high interest rates. Therefore, many national governments have been supporting renewable energy projects by providing them with cheaper capital. Thailand, for instance, has established the ENCON Fund, a revolving fund that has significantly reduced the

17 Hirth and Steckel (2016), IEA-RETD (2016), Deutsche Bank (2011), Temperton (2016)

Overview of the impact of economies of scale on individual project costs — Figure 3



LBNL 2016: https://emp.lbl.gov/sites/default/files/2016_wind_technologies_market_report_final_optimized.pdf cost of capital for RE investment. Loans have a maximum period of 7 years and they typically have a 4 percent interest rate or lower (compared to a market rate of 9 %).[18] Similar support is provided by Brazil's BNDES bank.[19]

Qualified workforce

Key insight: A qualified local workforce contributes to low-cost RE by reducing the need to import services and by lowering wage premiums. Furthermore, local companies often know the country's landscape better and can help avoid costly delays.

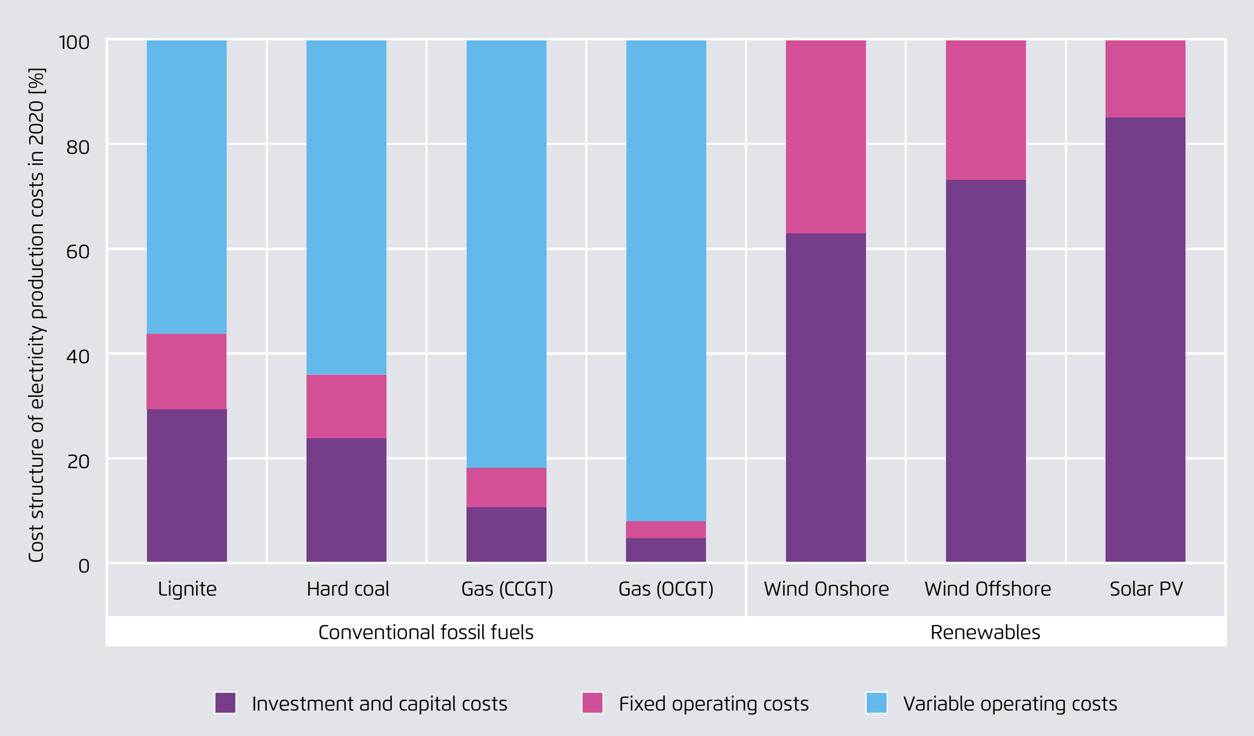
18 CCAP (2012), Frankfurt School (2012)

19 IRENA (2017)

Low cost RE doesn't just depend on a skilled and capable workforce in the private sector. In the public sector, as well, it is necessary to have policymakers and regulators who understand the issues and who can ensure that project development, including regulatory approvals, proceed in a timely manner. The presence of skilled labor is particularly important for utility companies, for in many cases, utilities have insufficient staff and in-house expertise to conduct a complex analysis of grid impacts and the optimal integration of renewables, among other issues.

Local contractors such as engineering firms often know a country's environment better than foreign service providers. Hiring local contractors can thus help to avoid costly delays. Indeed, nurturing a skilled workforce to meet the needs of the domestic renewable energy industry can facilitate stronger

Comparative cost structure of key power generating technologies — Figure 4



Note: The variable operating costs include, in particular, fuel costs and CO_2-pollution abatement costs (e.g. EU ETS certificates); Fixed operating costs include, in particular, the operation & maintenance as well as personnel costs, Source: Own calculations based on IEA/NEA (2015) partnerships and consortia, and, in turn, reduce renewable energy costs.

However, developing a skilled workforce cannot be achieved overnight. It is therefore crucial to invest in capacity building and local training institutes, including technical and engineering schools. Developing such resources should be seen as an investment in the long-term success of the renewable energy industry.

Availability of critical infrastructure

Key insight: Critical infrastructure such as ports and roads is necessary to support certain RE investments. Such infrastructure is often financed by local authorities and thus not reflected in the contract price.

In some jurisdictions, key infrastructure may not always be available, or may need to be upgraded, in order to enable the development of certain renewable energy projects. In some cases, this can be as simple as building a new road so that the trucks carrying wind turbine blades (some of which can exceed 80 meters in length) can reach the planned construction site. In other cases, this may involve costlier investments, such as upgrading port infrastructure or upgrading roads throughout a given region that were not originally designed to handle large loads.

Investment to develop such infrastructure is rarely reflected in the contract price. Governments around the world frequently make investments in key infrastructure to incentivize economic development. Thus, while such investment is not necessarily specific to the energy sector, it may be essential for the continued growth of domestic renewable energy. By making supportive infrastructure investments in a timely manner governments can help to ensure lower cost renewable energy development.

Qualified workforce and specialized contractors are a pre-requisite to realize renewable energy projects on time and at cost.

Transporting machinery and equipment requires a certain infrastructure, like ports and roads. Due to the size of some components as rotor blades and tower segments, wind projects have higher requirements than solar pv projects.

2.2 Regulatory factors

Continuing further up the pyramid, this section covers the four most important building blocks grouped under Regulatory Factors:

1. **Stable regulatory environment**
2. **Streamlined permitting and administrative procedures**
3. **Land access**
4. **Grid interconnection procedures**
5. **Other factors**

Stable regulatory environment

Key insight: As investors value predictability, a stable regulatory environment is one of the most important factors required for successful renewable energy development.

Each year the World Bank publishes its "ease of doing business" report in which it ranks different countries around the world in terms of how easy it is to run a business in a given country.[20] Chief among the factors evaluated is the overall stability and predictability of the regulatory environment. Investors value predictability, both in terms of project planning, permitting, and construction as well as in terms of the predictability of future cash flows. Key to such predictability is maintaining a stable regulatory environment with clear and reliable rules.

Countries that consistently rank high in the World Bank's report include Denmark, New Zealand, and Singapore. In these countries, rules and regulations are generally clear, and their application and enforcement are generally predictable. In its report, the World Bank stresses the importance of strong institutions that enforce rules in a predictable manner.

In order to strengthen the overall stability of the regulatory environment, governments should consider a range of measures:

→ the creation of independent regulatory agencies, which lead to the removal (or mitigation) of direct political interference by assigning key powers to

20 World Bank (2017b).

Streamlined permitting and administrative procedures are key to reduce both uncertainties regarding the lead times and the cost of renewable energy projects.

dedicated bodies, including one-stop-shop agencies responsible for dealing with renewable energy developers;

- the adoption (whether by law or administrative order) of clear processes for the updating or altering of rules and regulations, including the use of stakeholder consultations before major rule changes come into force;
- the publication of clear flow charts showing the full list of permits and authorizations required, including how much each step in the process is likely to cost, and how long it can be expected to take;
- the introduction of specific maximum limits on how long particular steps of the permitting or project evaluation process are allowed to take; and
- the involvement of a wide range of representatives from different agencies, including independent experts in the bid evaluation process (in jurisdictions where auctions are used), who can help mitigate regulatory risk by increasing trust.

Streamlined permitting and administrative procedures

Key insight: Simple administrative procedures, especially with regards to permitting, is a necessary component in order to reduce the uncertainty surrounding the lead times and administrative costs of RE projects.

Complex and lengthy administrative and permitting procedures involving a large number of authorities can result in high costs and long lead times for new renewable energy projects.[21] Simplifying these processes can effectively reduce costs.

Policymakers can reduce administrative and permitting barriers by establishing specific turn-around times for individual steps in the permitting process, thus placing pressure on each institution involved to deal with applications in a timely manner. A further step that can be used is the establishment of an agency that acts as a "one-stop shop" for all aspects related to permitting. The success of these changes is, however, conditional on the institutional capacity and expertise of the organizations involved. In addition, permitting costs can be reduced effectively

21 Ragwitz, Held et al. (2007), IEA-RETD (2013)

if renewable energy considerations are integrated in spatial planning decisions.

Land access

Key insight: Wind, PV, and hydro power projects require securing rights to considerable expanses of land. Accordingly, governments have begun establishing pre-packaged sites that include all land access rights, thereby mitigating a key RE cost component.

In recent auctions in the Jordan, Morocco, and India, bidders were invited to bid to develop renewable energy projects on pre-selected parcels of land for which the land rights had been previously secured and where the costs of grid connection were covered. In addition to reducing the costs and risks for developers, this approach has an added advantage of ensuring that bidders compete on an even playing field in terms of resource quality. A further advantage is that such sites can be coupled with grid expansion or with land rights for the construction of any transmission corridors required, thereby reducing another important cost component (see the section on "cost sharing methodology for grid connection" below). A downside of this approach, however, is that since all developers are required to build on the same plot of land, developers with access to better quality sites may lose a key competitive advantage.

In other jurisdictions, a clear planning and permitting process is used instead of pre-packaged sites, with clear rules governing aspects such as noise, flicker, or regulatory set-backs from houses (in the case of wind turbines), other rules relating to environmental protection (e. g. of endangered species), or water rights in the case of concentrating solar power (CSP) projects.

By reducing or even eliminating the costs of securing land rights, and clarifying the overall regime governing land access and land use (e. g. spatial planning), policymakers can help mitigate another important source of risk for investors and developers while further reducing the contracted price of renewable energy projects.

unsplash.com/efe kurnaz

As wind and solar projects require vast areas of land, accessing land is crucial to succeed with those projects. Inter alia, this includes spatial planning and securing land rights.

Grid connection procedures

Key insight: Clear grid connection procedures are crucial for reducing RE costs, as they can be as high as 25 % for offshore wind projects. Transparent connection procedures and cost sharing methods between grid operators and RE project developers are important for lowering risks and costs.

Grid connection costs can represent a significant share of overall project costs. This issue is particularly relevant in jurisdictions that have little prior experience with privately financed (or co-financed) electricity projects, as clear protocols may not exist for connecting to the national electricity grid. In the absence of clear protocols, including technical and operational guidelines, it may be difficult for developers and investors to predict how long the grid connection process might last, how much it will cost, who is responsible for paying which cost items, and how the interaction with the grid will work once the project begins operation.

Grid connection costs can vary significantly based on the cost sharing approach applied. What must be paid by the renewable energy developer and what must be paid by the grid operator or utility? In the past, legislators around the world have typically used the“deep”-connection charging approach for power plants. Under this approach, power producers have to pay for both grid connections and for grid reinforcement (i. e. if the existing transmission capacity is insufficient).

In recent years, the dominant trend has been to favor a“shallow”connection charging approach. Under this approach, producers of renewable electricity only have to pay for the grid connection to the nearest connection point. The cost of grid reinforcement is covered by the national grid operator (or utility). This approach has already considerably reduced grid connection costs in RE projects.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Grid connection is a challenge, in particular in remote areas. Transparent connection procedures and cost sharing methods between grid operators and RE project developers are important for lowering risks and costs.

Other factors
There are other relevant regulatory factors that are not discussed here, such as the stringency of environmental and social impact assessments, the presence or absence of import taxes on the equipment purchased, the presence or absence of sales taxes on the components or on the electricity itself, and the regulatory provisions governing the sale of electricity after the end of the power purchase agreement (RE projects typically have useful lives longer than the official contract period, enabling them to sell power well after the initial power purchase agreement, or PPA, expires). These various factors clearly also play an important role in determining RE project costs.

2.3 Contractual factors (PPAs)

This section covers the six most important building blocks grouped under "Contractual Factors":

1. **Solvent and reliable off-taker**
2. **Contract duration**
3. **Payment structure**
4. **Inflation indexation**
5. **Currency risk mitigation**
6. **Dispatch and curtailment rules**

Solvent and reliable off-taker

Key insight: To lower risks for RE producers, buyers of the electricity must be financially solvent. Governments can improve off-takers' solvency by sovereign guarantees and retail tariff levels that cover the costs of utilities.

In any long-term contract, the seller of a product runs the risk that the buyer is eventually not able to pay. This so-called off-taker or counterparty risk also exists for renewable energy producers under any long-term power purchase agreement. Thus, from a financial point of view it is important that the buyer of the renewable electricity is financially solvent. Governments can take a number of measures to improve the solvency of the off-taker, including providing sovereign guarantees and ensuring that the retail tariffs in place allow utilities to cover their costs.

There are different types of off-takers in different market settings. In liberalized electricity markets there are usually various options of selling the produced electricity, either via bi-lateral arrangements, the wholesale market, or third party aggregators. In single buyer markets (e.g. Brazil, South Africa, Indonesia), power producers can only sell their power to the central buyer, i.e. the utility. In those markets, the bankability of a project relies strongly on the overall creditworthiness of the off-taker, including the regularity and timeliness of payment, the extent of the off-taker's leverage, its ability to service its debts, and its continued ability to cover its overall costs of service by raising rates or cutting costs.[22]

Even in markets with an off-taker who is prepared to sign a long-term contract, additional policy measures may be needed, particularly if the underlying solvency of the utility or off-taker is in question. In some developing countries, investors may request that off-takers obtain sovereign guarantees, letters of support, or special guarantees from development banks or other international organizations, such as the World Bank's Multilateral Investment Guarantee Agency (MIGA).[23]

Contract duration

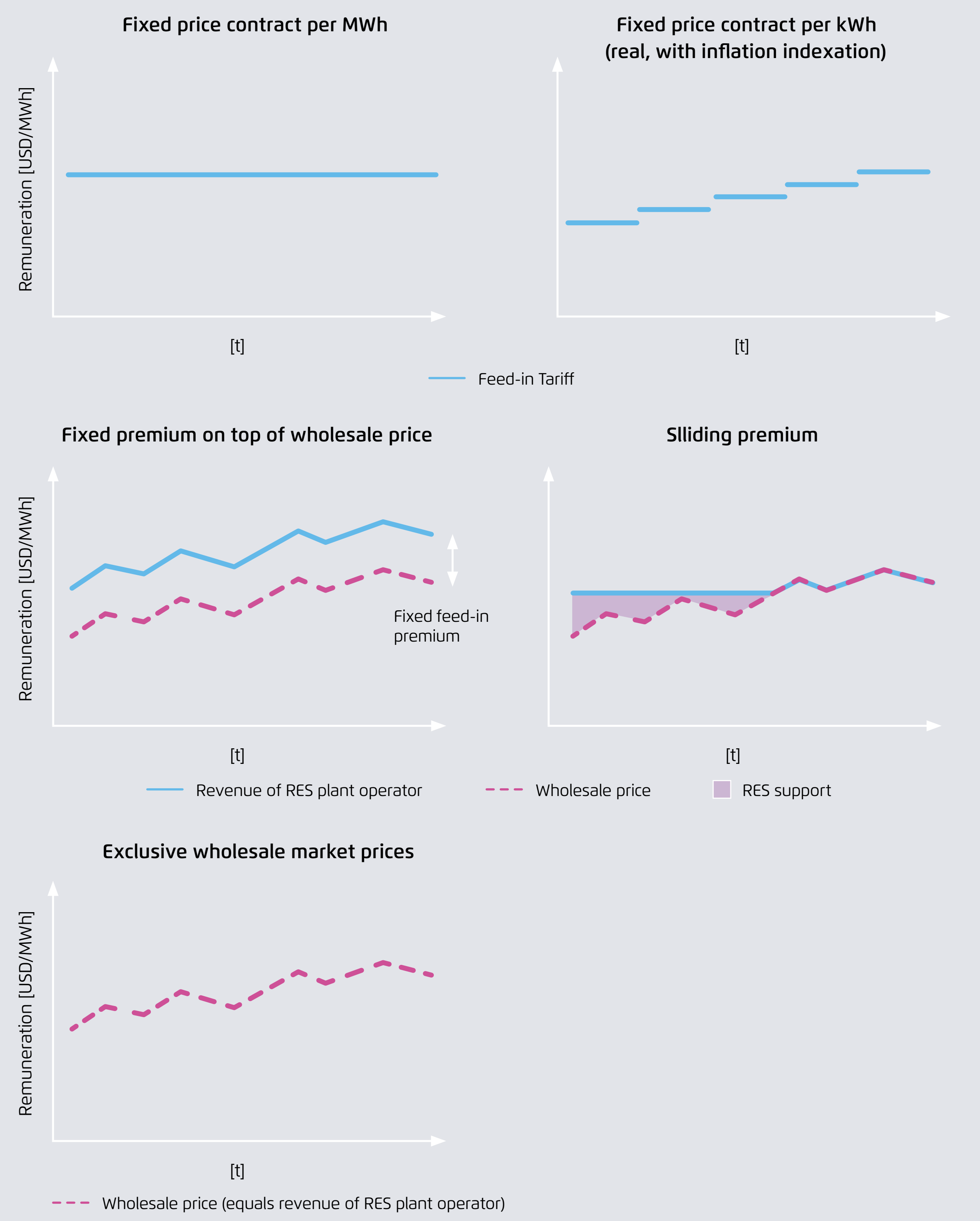
Key insight: Contract terms, under which project costs can be recovered over a longer long period, are crucial to reducing the levelized cost of renewable energy projects.

The contract term (or payment duration) is another important factor determining the cost per kilowatt-hour of renewable energy projects. Jurisdictions that

22 IEA-RETD (2016)

23 UNDP (2013)

Overview of different payment structures for renewable energy projects. Figure 5



Adapted from Couture and Gagnon (2010)

have achieved low prices for renewable energy projects (e.g. India, Mexico, Brazil, Germany, UAE), typically sign contracts that reflect the economic lifetime of renewable energy power plants. In the case of wind and solar PV, this usually results in power purchase agreements (PPAs) of 20 years or more.

Some jurisdictions have opted for shorter-term contracts (e.g. 5–10 years) or the potential to re-negotiate prices after a certain period. Even though these shorter-term contracts are sometimes signed with fossil fuel based power plants or for biomass plants (which have higher variable costs), they usually do not work for projects with high fixed costs, e.g. wind energy and solar PV. The project developer needs to know at the start of a project how the fixed costs can be recovered over its lifetime. Any uncertainty related to the duration of the contract can increase investment risks and therefore put upward pressure on the weighted average cost of capital (WACC).

Payment structure

Key insight: Record-low RE prices have been primarily achieved with contracts based on payment of a fixed price per kWh. The extent to which RE producers are exposed to price risk can play a significant role in determining the actual cost of RE to the off-taker, and therefore, the cost to consumers.

The payment structure of a power purchase agreement directly influences the overall risk of the investment and therefore has an important impact on the cost of capital (see section 2.1). In general, the following payment structures are used:

- → **Fixed price** payment per kilowatt-hour
- → **Sliding premium** payment on top of the hourly wholesale market price
- → **Fixed premium** payment on top of the hourly wholesale market price
- → Exclusive **wholesale market** prices (without any additional support)

Depending on which payment structure is adopted, investors face varying degrees of price and contract risk. Most of the recent low-cost auctions around the world, including India, Morocco, UAE included long-term contracts with fixed (and often escalating) prices (see below on inflation indexing).[24]

Inflation indexing

Key insight: Indexing PPAs to inflation reduces investors' price risk. However, including a high degree of inflation adjustment shifts the risk onto the utility or off-taker. While this reduces the cost of capital by protecting investors, it can increase long-term RE contract costs when inflation rises significantly.

Renewable energy projects are capital intensive. Accordingly, a large share of costs are incurred at the start of a project. These costs are not exposed to inflation risk. However, inflation can impact the variable costs – namely, as operations and maintenance expenses, fuel purchases (in the case of biomass), land lease payments, insurance, and so on.

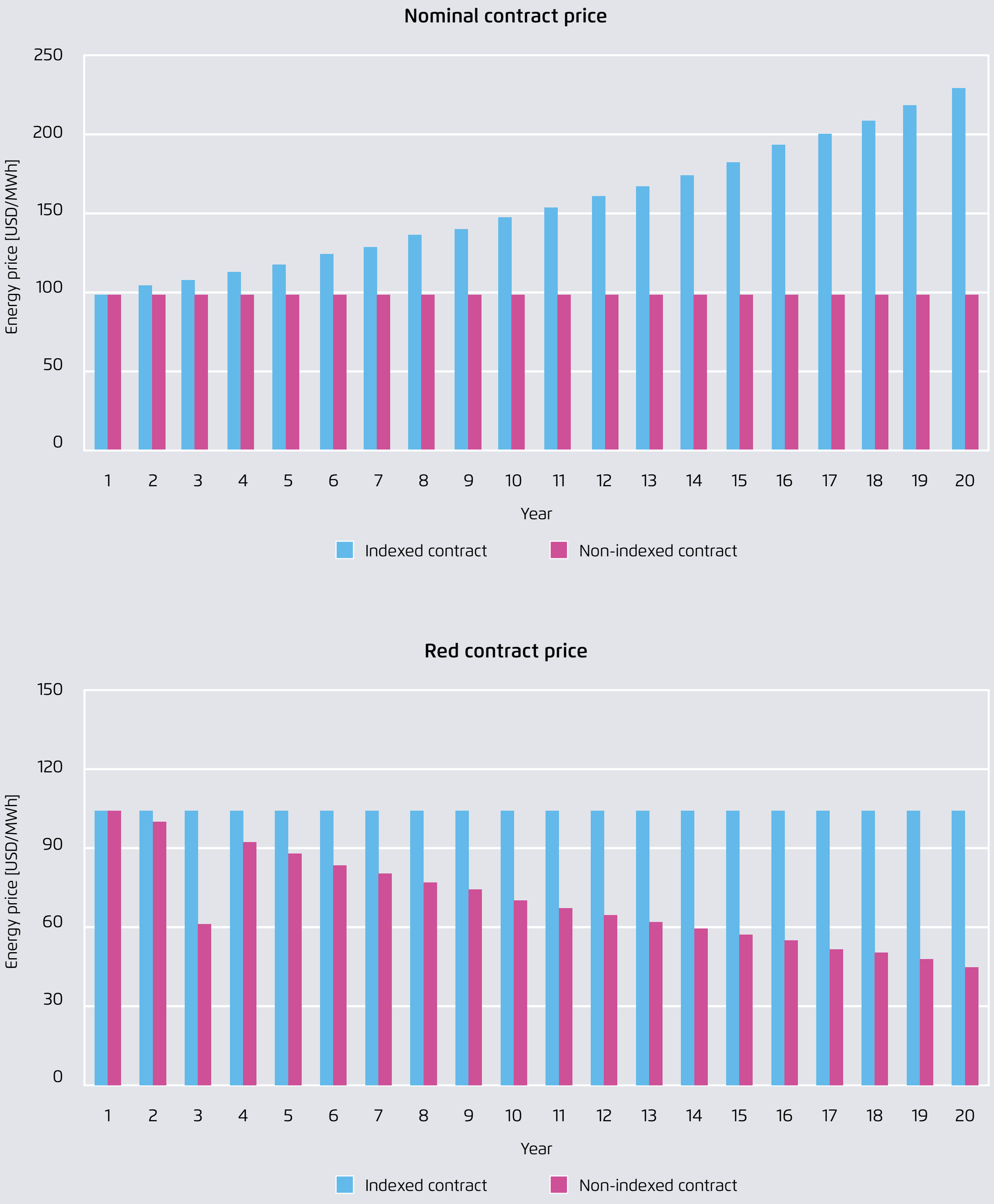
In order to mitigate inflation-related risk, some jurisdictions have indexed part or all of the remuneration of a renewable energy contract to inflation.[25] Indexing renewable energy contracts has an important effect on the "real" contract price and on the total cost to the utility or to ratepayers: depending on a jurisdiction's average inflation over the contract period, a nominal "un-indexed" contract price might represent only 50 % or less of the total value of the cash flows that would be generated from an inflation-indexed contract price (see figure 6 below).

Moreover, in most cases when PV and wind auction prices are quoted as "record-breaking," no mention is made of whether these prices are in nominal or real

24 IRENA (2017)

25 Couture, Cory et al. (2010), Jacobs (2012), Jacobs, Marzolf et al. (2013), UK LCCC (2017)

Impact of inflation indexing on the real contracted price of renewable energy projects. Figure 6



Adapted from (IRENA 2017: 11).

terms. In many cases, and indeed in most emerging markets, renewable energy contracts are adjusted fully or partially to inflation, which makes the initial quoted price misleading.

To draw on a few examples, Brazil, Peru and South Africa have all indexed their PPAs to inflation in recent renewable energy auctions. Thus, the quoted prices, once adjusted for inflation, will be significantly higher than those announced. Figure 6 provides an overview of the impact of inflation indexing on the total revenues generated by a project.

There is therefore an important trade-off between achieving low-cost renewables in the short-term (via a "real" or inflation-linked PPA price) and achieving low-cost renewables in the long-term via an initially slightly higher, but fixed or "nominal" PPA price over the 10 to 20-year contract period.

Currency risk mitigation

Key insight: To reduce investors' exposure to currency risk, RE contracts can be denominated in international currencies such as the USD or EUR. However, this could make a PPA more expensive if the local currency weakens.

Currency risk refers to the risk that the currency in which payment is guaranteed depreciates significantly, thereby eroding the real value of revenues earned. This risk is also often referred to as "exchange rate risk." Broadly speaking, policymakers can mitigate exchange rate risk in two ways:

1. Denominate the PPA in an international currency (e.g. USD or EUR)
2. Provide other forms of guarantees or supports (e.g. inflation adjustment) to mitigate the currency risk

For instance, Kenya has offered to pay contracts in US dollars, effectively making its national utility company responsible for currency risks.[26] In this way, the revenues generated by a project are earned in the same currency in which the majority of expenditures occur. By contrast, some jurisdictions such as Thailand[27] and Indonesia[28] have chosen to leave PPAs denominated in local currency and have left it up to developers to manage associated currency risks. Other jurisdictions such as Mexico offer developers a choice: they can either index contracts directly in US dollars, or to the Mexican inflation rate (Mayer Brown 2016).

Furthermore, some countries such as Nepal have even introduced two different PPA regimes: one for locally-owned companies paid out in local Nepal Rupees, and another for international companies that is paid out in US dollars.[29]

However, as with inflation risk, there is an important trade-off between reducing the risks to international investors in order to reduce the cost of international capital, and reducing the risks to the country itself (i.e. ratepayers) of significant future depreciation of the currency. Future currency weakness could make the low-cost RE contract signed today appear much more expensive tomorrow.

Dispatch and curtailment rules

Key insight: Clear rules and compensation mechanisms for dispatch and curtailment are necessary to provide long-term stability for investors.

Curtailment is a tool used by grid operators to reduce the power generated by specific power plants. Curtailment can be motivated by various situations, including inadequate electricity demand, the availability of alternative generation resources, the availability of transmission network capacity, and/or grid stability issues. The term "dispatch" refers to the order in which power plants are used to meet elec-

26 Nehme (2016)

27 WFW (2015)

28 Halstead et al. (2016)

29 The Asia Foundation (2013)

tricity demand. This is also known as the "merit order" or "dispatch curve." In liberalized power markets, power plants are generally activated according to their short-term marginal costs (which consist primarily of fuel costs).

Clear rules governing curtailment and dispatch are necessary to reduce the financing costs of renewable energy power producers. In many countries around the world, renewable energy producers are granted "priority dispatch" (i.e. renewable power is dispatched first, before any conventional power plant is taken into consideration).

Regulators and system operators need to develop clear rules describing in detail when curtailment of which plants is possible and what compensation is provided. From an investors' point of view, 100 % compensation in the case of curtailment is of course an ideal arrangement. However, in recent years some jurisdictions have moved to regimes in which only a fraction of the curtailed power is compensated. Since it is very difficult for power producers to anticipate where grid congestions might occur over the next 20 years, such rules can increase risk quite considerably.

To mitigate curtailment risks, policymakers have a number of options:
- → Define upper limits on allowable curtailment.
- → Provide full or partial compensation for curtailed power.
- → Reduce excess generation capacity in the system to reduce the frequency of curtailment events.
- → Improve demand-side management.
- → Reduce the number of "must-run" hours stipulated in conventional power generation contracts and introduce storage.[30]

30 IEA-RETD (2016)

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