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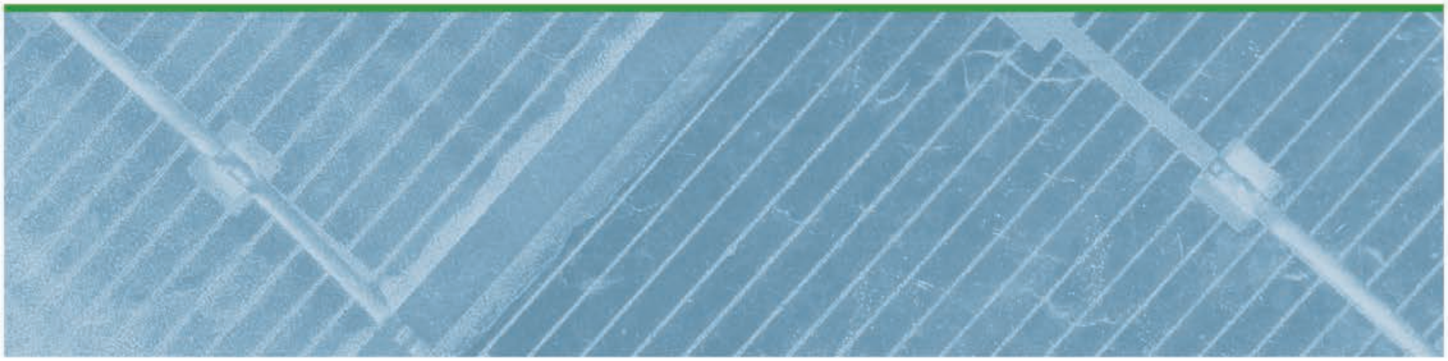

SOLAR POWER

POLICY OVERVIEW AND GOOD PRACTICES

Sadie Cox, Terri Walters, and Sean Esterly
National Renewable Energy Laboratory

Sarah Booth
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Prepared for the U.S. Department of Energy and the Australian Government Office of Industry and Science

NREL/TP-6A20-64178
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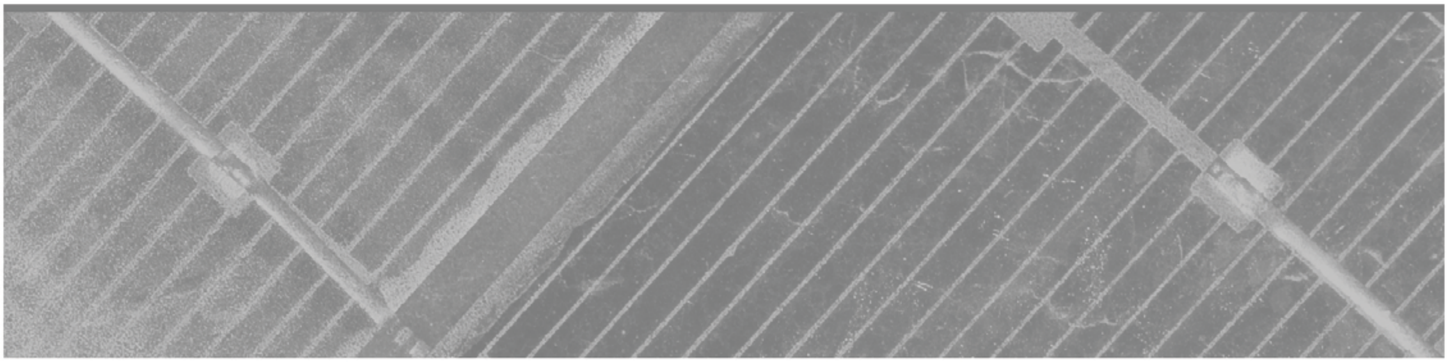

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NOTICE

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Introduction

As global electricity demand increases, governments are designing and implementing policies to scale up and catalyze renewable energy, which now meets 22% of global electricity demand (REN21 2014). Solar technologies are a critical component of this expanded deployment, and they have experienced unprecedented growth in recent years. As presented in Figure 1, solar prices have decreased significantly over the last decade (REN21 2014) and in 2013, new capacity installation of solar electricity from photovoltaics (PV)[1] surpassed all other renewable energy technologies worldwide—excluding hydropower—with 39 gigawatts installed that year. Concentrating solar thermal power,[2] although it still represents a fairly nascent market, also continues to expand as installed capacity increased by 36% in 2013 compared to 2012. In addition to meeting energy demand in an increasingly cost-effective manner, solar deployment can also support critical economic, social, and environmental development goals (Flavin and Hull Aeck, n.d.).

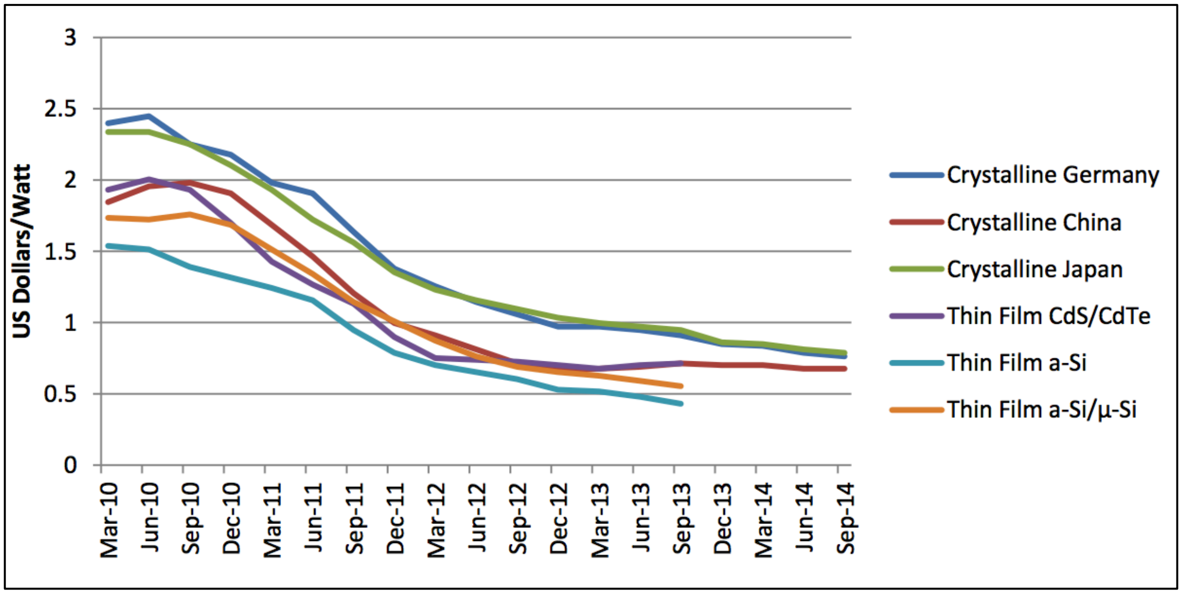

Figure 1. Average PV module prices (2010–2014)

Source: Stark et al. 2015, adapted from pvXchange 2014

Despite significant growth of solar markets in many countries, barriers to solar deployment still exist. Common critical barriers[3] include:

- Lack of consistent policy signals, which can create uncertainty in markets
- Restrictive and time-consuming regulatory and permitting processes
- Technical or infrastructural grid integration challenges
- Concerns of utilities related to integration of distributed or variable power in the grid

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[1] Photovoltaics are a method of generating electrical power by converting sunlight directly into electricity through semiconducting solar panels. For more information, see www.nrel.gov/learning/re_photovoltaics.html.

[2] Concentrating solar power technology focuses solar thermal power using mirrors or lenses and then converts the energy to heat a steam turbine for power generation. For more information, see www.nrel.gov/learning/re_csp.html.

[3] Barriers drawn from Brown and Muller (2011), REN21 (2014), and U.S. Dept. of Energy (2014).

- Higher cost of solar technologies (real or perceived),[4] especially in relation to fossil fuel subsidies
- Lack of affordable financing
- Need for skilled labor to support solar technology deployment, including system design, installation, and ongoing operation and maintenance.

It is within this context that policymakers are seeking to learn from successful solar deployment approaches around the world. As part of the Solutions Center's *Clean Energy Policy Brief Series* that describes key policy design elements across renewable energy technologies, this paper presents approaches and considerations specific to solar deployment. Drawing from international experience and lessons, the paper focuses on solar-specific good practices for renewable electricity standards (RES), feed-in tariffs (FIT), auctions and tendering processes, interconnection and net metering, financial incentives, and further approaches to enable private finance. Ultimately, governments can design a suite of complementary policies that aligns most appropriately with unique national circumstances and goals.

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[4] As PV prices continue to decline, cost considerations are becoming less of a barrier to deployment in several contexts. However, perceived cost competitiveness issues still present significant challenges to broadening PV support. Upfront capital costs also remain a challenge in certain contexts.

Enabling Solar Policies

Governments around the world are developing renewable energy policies to support broader national goals such as diversifying energy supply, enhancing energy security, expanding energy access, fostering innovation, and addressing global climate change. While these policies share key design elements across renewable energy technologies, the good practices and considerations described in this section can support policies tailored to expand solar deployment within the context of country-specific challenges and opportunities.

Renewable Electricity Standards and Solar Set-Asides

Renewable electricity standards (RESs) are regulatory mandates that require that a specified amount of electricity sold or generated within a given area come from eligible renewable resources. The Solutions Center's RES policy brief[5] provides a full overview of the policy and related best practices, which are summarized in Text Box 1.

Several countries have established targets to specifically support solar deployment, including the recent adoptions or revisions presented in Table 2 (REN21 2014). Building on these targets, countries are increasingly designing solar set-asides within their RESs to provide targeted support of solar technologies. Without solar set-asides, the least cost renewable energy technologies will typically be favored under an RES. Therefore, set-asides are crucial to support solar investment when solar costs are higher than other available renewable energy options, and they can be particularly beneficial for distributed solar projects. RESs that include a solar set-aside provide a market signal that a country is prioritizing solar deployment.

Text Box 1. Key RES design elements across renewable energy technologies

- *Conducting technical and economic analysis* in relation to resource supply and quality, costs, siting, transmission and distribution, policy environment, and possible economic, social, and environmental impacts
- *Identifying eligible resources and technologies* that will be most beneficial in supporting policy goals, as well as technologies that may require targeted support
- *Setting RES targets* that are appropriate for national circumstances and the long term, and are scaled up over time
- *Clearly defining the standard* to ensure optimal renewable energy deployment outcomes
- *Establishing a compliance mechanism and cost control provision* by balancing the cost to comply and the overall benefit of compliance (e.g., local economic growth)
- *Designing a tradable renewable energy credit (REC) system* to support robust, accurate, and efficient tracking and accounting of renewable energy generation

For a full description of key RES design elements, see cleanenergysolutions.org/policy-briefs/res.

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[5] See cleanenergysolutions.org/policy-briefs/res.

Table 1. Recent Solar Target Adoptions or Revisions

Country	Cumulative Target
Algeria	13.5 gigawatts (GW) of PV and 2 GW of concentrating solar power (CSP) installed by 2030
China	100 gigawatts (GW) of PV installed by 2020 and 20 GW of distributed PV by 2015
Egypt	700 MW of PV and 2.8 GW of CSP installed by 2017
India	100 GW of installed solar capacity by 2022
Indonesia	80 MW of PV installed by 2025

Good Practices and Considerations

Drawing from existing experience with solar set asides and building on broader RES key design elements across renewable energy technologies, several good practices and considerations can support development of effective solar set asides. The following practices are flexible and can be tailored to specific country circumstances.

- *Sending incremental and consistent policy signals to encourage gradual increases in solar deployment*—Most solar set asides include deployment targets to be met in interim years. For example, an RES that has a solar set-aside of 5% by 2030 may have targets of 1% by 2015 and 3% by 2020. These interim targets send a market signal that there will be ongoing demand for solar and encourage steady market growth. Text Box 2 describes Chile's efforts to support a long-term vision for solar deployment through increasing interim solar targets over time and evaluating the broader enabling environment.
- *Setting appropriate and declining alternative compliance payment (ACP) rates*—Differentiating them from solar targets, solar set-asides include a non-compliance penalty or ACP. As compared to other technologies, solar set-asides often require higher ACP rates to align with costs of solar electricity and distributed generation. However, solar ACP rates are also often established to decline over time. Declining ACPs reflect projections for

Text Box 2. Chile: Increasing targets over time to support a long-term vision for solar deployment

In 2008, Chile enacted the Non-Conventional Renewable Energy Law requiring electricity providers to use renewable energy, including PV and CSP, for 5% of total generation from 2010 to 2014. Beginning in 2015, the requirement will increase by 0.5% each year through 2024, with monthly fees levied for non-compliance. These targets support Chile's overall vision for solar deployment and send a consistent and long-term policy signal (Non-Conventional Renewable Energy Law, 20.257 - www.iea.org/policiesandmeasures/pams/chile/name-24577-en.php and Chile Ministry of Energy 2012)

To support Chile's solar targets, the Government of Chile Economic Development Agency (CORFO), is leading a solar power industry development program. Through this initiative, CORFO and the Chile Renewable Energy Center (CER) partnered with the Clean Energy Solutions Center to evaluate the country's solar energy plan and assess needs related to the legal framework, diffusion of information, financing, research and development, and human capital development. (Clean Energy Solutions Center).

declining solar prices over time and can incentivize lower solar installation costs and solar renewable energy certificate (REC)[6] prices (Leon 2012). If solar ACPs are set too low, they will not successfully drive solar deployment (Philibert 2011).

- *Designing solar-specific RECs to meet solar set-aside requirement*—Solar generation RECs can also be established as a compliance mechanism (Wiser et al 2010). However, policymakers should keep in mind that complying entities may only purchase RECs under short-term contracts unless they are incentivized or required to enter into longer-term contracts. Policymakers should also be aware of possible challenges related to linking solar RECs with spot market prices, as this creates uncertainty for solar financiers and may decrease investment. These challenges can be mitigated through developing longer-term ACP schedules, setting a minimum price or floor for solar RECs, and encouraging or mandating longer-term REC contracts (Bird et al. 2011).
- *Establishing net metering and interconnection standards to complement solar RES; scaling up solar deployment requires development of multi-faceted policy packages*—In the case of RESs, complementary net metering and interconnection standards can be particularly beneficial in supporting successful outcomes. Good practices associated with net metering and interconnections are described below (Steward and Doris 2014).
- *Considering project size, location, and land use*—When designing solar set-asides, policymakers may also develop guidelines or rules regarding the location of large-scale solar power plants to ensure that agricultural and other rural land use sectors are not impacted (Leon 2012). In some solar set-asides, a certain portion of the requirement must be met with distributed solar projects rather than large projects. Policymakers can determine whether the land use effects and grid reliability benefits of distributed generation warrant such an additional requirement.

Text Box 3. Key FIT design elements across renewable energy technologies

- *Setting and revising FIT payment levels* in relation to technology, resource quality, project size, and location and adjusting policies in a predictable manner
- *Considering a cost containment approach* to avoid boom-and-bust scenarios
- *Establishing long-term contracts and guaranteeing grid access* to lower investor risk and cost of financing. Siting incentives and grid connection cost sharing can also support positive outcomes related to guaranteeing grid access
- *Considering forecasting requirements* to support grid operators in balancing renewable energy generation with system demand
- *Streamlining administration and approvals* to avoid barriers and reduce time and costs associated with project development

For a full description of key FIT design elements, see cleanenergysolutions.org/policy-briefs/fit.

Feed-in Tariffs

FITs are designed to increase deployment of renewable energy technologies by offering long-term purchase agreements for electricity generation at specified prices, thereby providing market certainty for developers (Couture et al. 2010). Text Box 3 summarized FIT policy design elements.

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[6] A Renewable Energy Credit (REC) represents the environmental attributes associated with one megawatt-hour (MWh) of electricity production. RECs can be traded, bought, and sold separately from commodity electricity.

As of 2013, 56 countries had adopted solar FITs making them one of the most widely used policies to support solar investment (REN21).[7] Over the last few decades, countries have engaged in a process of "learning by doing" as they designed and implemented solar FITs (Rickerson 2012). As solar prices have decreased rapidly, several new challenges and opportunities have emerged to inform FIT design. Within this context and based on international experience, good practices and considerations for solar FIT design and implementation are highlighted in the next section.

Good Practices and Considerations

Lessons and good practices from countries that have adopted FITs can inform similar efforts in other countries, and they can be tailored to meet country-specific goals. The following practices and considerations build on international experience and can be adapted to address unique country circumstances.

Text Box 4. United Kingdom: FIT degression to support stable, yet iterative policy evolution and solar market growth

To support a stable, yet flexible, FIT policy environment, the United Kingdom designed a solar FIT degression approach with pre-planned tariff decreases of 3.5% occurring quarterly. However, during times of low PV deployment, price decreases can be skipped for up to two consecutive quarters. Conversely, when deployment is higher than expected, the FIT degression can be increased up to a set percentage. In addition, the UK government reviews tariffs annually to ensure they align with overall policy goals as market dynamics evolve. For more information, see www.fitariffs.co.uk/eligible/levels/degression/

- *Linking solar FITs to high-level solar targets and a strong policy framework*—As FITs often require regular revisions and price changes, it is important that FITs are linked with broader solar targets and exist within a strong renewable energy policy framework with high-level government support. Foundational solar and renewable energy policies will help improve investor confidence during times of policy and tariff adjustment and will send a critical signal to the market regarding long-term solar support (Fulton and Mellquist 2011).
- *Predictably and gradually decreasing solar FIT prices*—As solar prices continue to fall, establishing a FIT price that predictably and transparently decreases over time can support stable market growth, enhance investor confidence, and support movement of solar prices to grid parity (Rickerson 2012). Policymakers may choose to set a pre-established percentage for annual declines in a solar FIT payment, as well as less frequent broader policy revisions. Policymakers may also consider linking the decline in FIT payment to market prices. Detailed collection of solar data related to technology market evolution and prices can also inform FIT tariff adjustments (Rickerson 2012; Fulton et al. 2011; Couture et al. 2015). Text Box 4 presents key design elements of the United Kingdom's FIT degression approach.
- *Understanding the benefits and value of solar*—To inform development of solar FITs, policymakers can consider broader environmental, development, and social benefits that may offset some associated costs and possible electricity rate increases. In addition, policymakers have recently placed renewed attention on valuing solar and its contribution to the electricity system. Using a broader set of avoided cost inputs (e.g., distribution, transmission, operation and maintenance, environmental), policymakers can transparently determine a price for solar.

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[7] For a current list of countries, see the REN21 Renewables Interactive Map (map.ren21.net). FITs are most common in Europe and Asia.

However, this approach could present challenges related to overpayment and must be carefully considered in relation to specific local circumstances.[8]

- *Considering linkages with other policies*—In some markets, policymakers are considering links between solar FITs and other support policies, such as tender and auction processes and net metering. In some cases, auction processes are being leveraged to support price setting for solar FITs. Under this approach, a government or utility can request bids for solar projects and choose multiple winning bids until total capacity equals a predetermined tender capacity goal. When compared with traditional FIT payment schemes, this competitive bidding can result in lower project costs (Philibert 2011). FITs and auctions can also be coupled in relation to project size, with FITs supporting smaller solar projects and auctions supporting larger projects. Text Box 5 highlights Malaysia's approach to assess trade-offs of linking FITs with auction-based approaches and describes some key lessons.[9] In some island nations, and in relation to specific market circumstances, policymakers are also developing hybrid FIT and net metering approaches to compensate PV owners selling back to the grid where grid power is more expensive than PV. However, these cases are very context-specific. As solar markets evolve differently in various country contexts, policymakers can consider links between solar policies that may enhance deployment opportunities (Miller et al. 2013; Couture et al. 2015). Text Box 6 highlights the partnership between the Government of Nepal and the Clean Energy Solutions Center to consider a linked solar FIT and reverse auction policy.

Text Box 5. Malaysia: Assessing policy trade-offs and options to inform FIT design

The Clean Energy Solutions Center partnered with the Government of Malaysia to support adjustments to their FIT policy in light of the rapid cost reductions taking place in the solar industry worldwide. The Malaysia Sustainable Energy Development Authority, with assistance from the Clean Energy Solutions Center, held several workshops to assess the trade-offs of FITs and competitive tendering for solar PV projects based on global experiences. To ensure smaller scale developers were not excluded, the partnership assessed approaches to avoid the consumption of all available capacity by large solar PV projects (i.e., greater than 5 MW) and facilitate competition of larger scale developers outside the FIT quota.

The workshops were instrumental in establishing a clear pathway toward competitive tendering for larger solar PV projects, outside of the existing FIT framework, and they built on global experience with renewable energy policies, as well as with competitive tendering to avoid some of the pitfalls and risks of tendering processes, such as high contract failure rates. Ultimately, FIT revisions will ensure a more sustainable footing for larger-scale solar PV development in the country, an essential part of reaching higher levels of renewable energy penetration in the years ahead (Clean Energy Solutions Center).

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[8] See "The Value of Solar: Old Wine in New Bottles," by Toby D. Couture published May 12, 2014 at www.renewableenergyworld.com/rea/news/article/2014/05/the-value-of-solar-old-wine-in-new-bottles.

[9] For more information, see cleanenergysolutions.org/expert/impacts/helping-malaysia-reduce-its-power-generation-carbon-footprint.

Auctions/Tendering Processes

Auctions and tenders for contracts help enable a competitive environment to procure renewable electricity through a defined selection process. Under this approach, governments tender or request bids for projects from which a utility or distribution company will purchase electricity. Tenders are usually designed with a total capacity of projects that will be funded, with the government or utility choosing multiple winning bids until the total capacity equals the tender capacity goals. Competitive bidding often results in lower project costs than traditional FIT payment schemes (Philibert 2011). Further, long-term contracts established under auction or tender processes often reduce overall policy costs through increasing competition and procurement efficiency, reducing payment levels, and more accurately reflecting prices in dynamic markets. In areas of high renewable energy penetration, tendered contracts can also allow for participation of renewable energy in centralized day-ahead and intra-day power markets, supporting optimized dispatch (Miller et al. 2013). However, transaction and administration costs to design and establish bidding processes can be higher than traditional renewable energy support policies. In all cases, design of tender and bidding processes will be very dependent on specific and unique market circumstances within various jurisdictions and countries (Maurer et al. 2011; Bird et al. 2012; Miller et al. 2013; Couture et al. 2015).

Text Box 6. Nepal: Considering links between FITs and reverse auctions

To support Nepal's consideration of a solar FIT and building on Nepal's small hydropower FIT implemented in 2013 (BNEF 2014), the Clean Energy Solutions Center partnered with Government of Nepal in 2014 to evaluate solar FIT design options. The effort specifically supported consideration of combined FIT and reverse auction approaches as well as evaluation of successful solar business models. Activities under the partnership have informed Government of Nepal solar policies and programs, including design of the Asian Development Bank photovoltaic investment initiative with Nepal (Clean Energy Solutions Center).

Good Practices and Considerations

Drawing from international experience and within the context of specific country circumstances, the following good practices and considerations can inform design of auction and tendering processes for renewable energy.

- *Considering project size*—For solar, competitive bidding processes are often most beneficial for larger-scale projects. With varying installation costs across larger solar projects, providing a dynamic environment to procure electricity is often more efficient. Auctions for utility scale solar can also help reduce potential ratepayer impacts by controlling overall deployment level. On the other hand, auctions are not regularly used for smaller-scale or residential solar projects. For these projects, complexity and costs associated with designing and administering an auction could outweigh the benefits described above (Bird et al. 2012).
- *Minimizing policy costs through effective design*—Various design elements can be incorporated to minimize costs associated with auction processes. For instance, a reverse auction approach often reduces costs by allowing project developers to submit bids that align with the required payment level to support a project for a set period (Miller et al. 2013). Reverse auctions are one of the most common tendering approaches to support large-scale solar deployment (REN21 2014). However, as noted above, design of auctions is highly dependent on local and unique market conditions in specific countries and jurisdictions (Maurer et al. 2011).

- *Facilitating participation by providing transparent, timely, and consistent information*—Openly and transparently communicating comprehensive and accurate auction information to project developers can support successful policy outcomes and facilitate the entrance of bidders, allowing for a more competitive auction environment. Clear procurement definitions, auction rules and penalties, and guidance for submitting bids can be provided well in advance of the auction to allow project developers time to evaluate the information and, in some cases, provide feedback or input related to the information. Policymakers may also consider providing workshops or trainings on the auction process to educate stakeholders, increase participation, and support successful outcomes.

  Policymakers can also support greater participation by providing a stable auction environment (i.e., reducing unexpected changes to the process and rules). Building on lessons learned over time, revisions to the auction process can be made transparently to support ongoing investor confidence. Finally, policymakers can also design monitoring systems to ensure appropriate bidding behavior (Maurer et al. 2011).

- *Ensuring developer experience and technical capability*—In some cases, auctions can encourage inexperienced developers to submit bids that are too low, resulting in a project that is ultimately unsuccessful. Policymakers can mitigate this problem through designing a two-phase tender process that requires bidders to demonstrate experience and technical capability before they submit a complete bid (Couture et al. 2010; Couture et al. 2015).

Net Metering

Net metering is a tariff-based policy that determines the value of excess electricity returned to the utility grid by a customer who uses electricity from an on-site renewable energy system. Net metering typically allows a customer's power production to be subtracted from power usage with the remaining amount (at the end of the billing cycle) determining the "net" kilowatt-hours (kWh) for which the utility bills the customer, regardless of when the electricity was produced or used. If customers produce more energy than they use in a billing cycle, the excess kWh produced can be "rolled over" as a credit to the next billing cycle or the utility can pay for the excess power at a specific rate.

Well-designed net metering policies can be effective in supporting distributed solar electricity markets. Coupled with simplified interconnection standards, net metering can ensure that utility customers who lease or own small-scale distributed renewable energy technologies receive value for energy they produce and feed back to the grid. While these can be relatively simple policies, appropriate design and implementation is critical in ensuring successful distributed solar energy markets. Net metering is particularly important for solar power, as it creates a value stream and offsets costs associated with residential-scale PV, which in turn builds public support for the technology.

Good Practices and Considerations

Several good practices and considerations, described below, are emerging from country experience implementing net metering policies. However, effective net metering policies should be tailored to specific market circumstances and policy goals.

- *Ensuring inclusive eligibility*—In general, to support successful interconnection and net metering policies, all solar technologies—and all other renewable energy, including combined heat and power technologies—are considered for eligibility. Further, net metering policies provide more market options and flexibility if all customer classes, including customers with third party owned systems are eligible for participation. Extending net metering policies to all utilities provides a more robust opportunity for the market to develop (Varnado and Michael 2009; Barnes and Varnado 2010; Barnes et al. 2013).

- *Setting appropriate capacity limits*—Policymakers often set limits on the size of individual systems and on overall capacity allowed to be net-metered on the grid. Individual system limits based on on-site consumer loads rather than arbitrary caps expand the market to more applications. System-wide capacity caps account for engineering limits for grid stability, but caps that are more restrictive reduce the market potential. Both of these limits can also take into account broader policy goals. For example, if a net metering program is focused on deployment of small-scale residential PV, large-scale renewable energy projects could lead to the capacity cap being reached without meeting the broader policy goal of small-scale deployment. Thus, policymakers may also consider a tiered policy based on project size or complexity, especially for smaller-scale PV generation (Varnado and Michael 2009; Barnes and Varnado 2010; Barnes et al. 2013).
- *Designing appropriate billing approaches*—An effectively designed net metering policy will allow customers with a renewable energy power system to consume power from the grid as needed to meet their load and to send power back to the grid when they produce more than they need. Under this approach, the customer is billed only for the “net” electricity that is used within a billing cycle. If a customer provides more power to the grid than is used during a billing cycle, the “excess” power can be rolled over to the next billing cycle. Customers can roll over excess credits for some period of time, often one year, at which point any remaining excess power will be reimbursed at a rate equal to or greater than the average wholesale rate of electricity. For any kilowatt-hours not compensated at the retail rate, effective policies address the ownership of RECs to ensure equitable treatment (California Center for Sustainable Energy and the Energy Policy Initiatives Center 2013).
- *Considering aggregate net metering approaches*—Aggregate net metering allows for aggregation of metering across various separate PV systems or across various customers for a single system. Allowing flexibility in configuration of the location of generation and which customers it serves can use solar resources more efficiently. Under this type of approach, community members and businesses can “subscribe” or purchase a certain amount of the power produced by PV systems in the community and thus receive credits on their utility bills for power produced. Such “community solar gardens” provide communities and local governments with an innovative approach to support more efficient system level outcomes (Barnes 2013). Aggregation can expand the customer base for solar since it allows solar use by customers who cannot install their own system due to a poor solar resource, lack of available space, rental restrictions, or other reasons. The aggregate net metering market is expanding globally, and as one example, a 2015 analysis found that in 2020 shared community solar could make up 32–49% of the distributed PV market in the United States (Feldman et al. 2015).

Interconnection Standards

Interconnection standards detail the conditions under which power generation owned by entities other than the utility are allowed to connect to the utility grid. They are intended to provide clear guidelines to ensure grid reliability while reducing costs and delays for generation projects. Interconnection standards are a prerequisite for the success of the solar policies described in this paper—particularly tariff-based policies—and they are critical in supporting distributed solar electricity markets.

All renewable energy projects need the legal authority to interconnect to the grid. While larger projects may involve engineering studies and in-depth consultation with utilities and regulatory entities, small renewable energy projects do not normally need to be held to the same complex standards, with aggregate net metering approaches as a possible exception. Standardized interconnection policies are particularly important for distributed generation, as they ensure all renewable electricity projects can connect to the grid if they meet certain technical requirements to ensure safety. The policies standardize connection procedures, technical requirements, and other issues. They also typically provide highly simplified procedures and forms for small systems.

Good Practices and Considerations

Interconnection standard policies are well established in several countries. Drawing from global experience, the following good practices and considerations can inform design of effective interconnection policies.

- *Designing a standardized interconnection policy*—To avoid inequity among systems, uncertainty in the market, and high costs and delays for distributed energy projects, a standardized interconnection policy can be developed rather than considering interconnection on a case-by-case basis. Utility operators have a responsibility to ensure the utility grid is reliable and safe, and therefore must have input on requirements for interconnection. However, because a negative incentive often exists for utilities to interconnect private generation, these standards are typically developed under regulatory or legislative authority. An effective standardized interconnection policy provides equal access to all developers, includes appropriate technical requirements for interconnection, and creates a simplified and low-cost method for small-scale renewable generation to connect to the utility grid.
- *Ensuring comprehensive policy coverage*—Under an effective interconnection policy, all utilities adopt the standardized policy, all renewable energy technologies are eligible for interconnection, and all customer classes are eligible for self-generation.
- *Setting appropriate capacity limits*—Policymakers often set limits on the size of individual systems and on overall capacity for interconnection to the grid. These limits are based on engineering limits related to grid stability rather than arbitrary caps. Effective interconnection standards do not require disconnect switches for smaller, inverter-based systems that meet certain technical requirements.
- *Reducing administrative and application costs*—When designing interconnection policies, procedures can be established to keep application costs to a minimum. Such procedures might include simplified forms, and fast-tracked applications and approvals for less complex systems. Ultimately, policymakers can design administrative processes and procedures to be transparent, uniform, accessible, and expeditious.

Solar Investment and Production Tax Credits

At least 25 countries have adopted investment and production tax incentives to support solar technology deployment.[10] Investment tax credits (ITCs) reduce the tax liability for owners of solar projects based on the capital investment in the project (Mendelsohn and Kreycik 2012). ITCs have relatively low transaction costs and are particularly effective in addressing the risks associated with early deployment technologies that have high up-front costs (Philibert 2011). For production tax credits (PTCs), the total tax incentive received is determined by multiplying the incentive level (per kilowatt-hour) by the amount of electricity generated by the eligible project, instead of by the investment in the project itself as with an ITC. The benefit of PTCs is that they incentivize optimal performance from solar plants, encouraging plant owners to invest in quality equipment and ensure proper maintenance of the facility.[11]

Text Box 7. United States: ITC and loan guarantees as a key driver of solar investment

The United States' solar ITC was revised in 2005, 2008, and 2009 to increase the credit amount from 10% to 30%, expand eligibility to investor-owned utilities, and extend the year through which it can be claimed to 2016 (Mendelsohn and Kreycik 2012). Under the U.S. ITC, there is no maximum incentive that can be claimed for solar energy projects (DSIRE 2014); however, owners receiving an ITC must maintain project ownership for five years of commercial operation or the government will reclaim a portion of the credit relative to the years of ownership. The owner can take the tax credit in the first year in which the plant is operational. The ITC is an instrumental driver of utility-scale solar projects in the United States, and the anticipated reduction in 2017 is expected to have a significant impact on the industry. (Parnell 2014).

The U.S. Department of Energy's (DOE) 1705 renewable energy loan guarantee program, established in 2009 as a part of the American Recovery and Reinvestment Act, has successfully increased innovation and investment in utility scale PV and CSP (Philibert 2011). To limit the cost to the government, the policy required eligible project construction to begin no later than September 30, 2011. Additionally, the maximum guarantee was 80% of total project costs, and the government explicitly did not assume any risks associated with pre-construction (DOE 2009). To increase expediency of loan provision to qualified projects under the program, the DOE established the Financial Institution Partnership Program, which identified qualified private lenders eligible to participate (DOE 2009). Borrowers applied for loans directly with eligible lenders, with DOE reviewing all applications. Approximately $13 billion in loans, about 80% of all loan guarantees under the program, went to solar investments, primarily generation projects (Brown 2011). Overall, DOE's renewable energy loan guarantee programs have resulted in substantial increased deployment and losses of only 2.3% of total commitments (Davidson 2014).

Good Practices and Considerations

When developing investment and production tax credits, policymakers can consider the good practices and considerations that are highlighted in this section and are drawn from international experience.

- *Establishing an appropriate incentive rate and controlling costs*—Generally, higher tax credit rates may be more likely to drive solar

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[10] At least one country on each continent currently uses tax incentives to support solar technologies. For a current list of countries, see the International Energy Agency's Policies and Measures Database (www.iea.org/policiesandmeasures/renewableenergy)

[11] For a tax incentive program to be effective, the investors must have a tax liability. If the developer of the project does not have sufficient tax liability to take advantage of the tax incentive in its entirety, it may be necessary to bring in a tax equity investor that can utilize the full benefit. This process increases the transaction costs, and, essentially, reduces the value of the credit (Mendelsohn and Kreycik 2012).

deployment, but will, of course, result in some loss of government tax revenue. Thus, establishing an appropriate tax incentive rate is highly dependent on various country circumstances and is not considered at length in this report. To control costs, policymakers may consider establishing a maximum incentive, either by individual project or for the entire program, to cap the credits provided. To date, government costs associated with solar tax incentives have not greatly exceeded cost projections (Brown and Muller 2011).[12]

- *Determining the tax incentive period and addressing other challenges*—Policymakers can establish an appropriate tax incentive period to ensure policy objectives are achieved. For instance, in cases where deployment of utility-scale solar projects is a priority, especially in countries with nascent solar markets, project development may occur over multiple years. Thus, the timeframe can be set accordingly to incentivize longer-term project developers to participate. Conversely, if policymakers seek to drive rapid deployment, a very long timeframe could reduce the incentive for near-term project development. Policymakers can also allow developers to receive tax credits at a certain stage of construction rather than at project completion to incentivize development that may occur beyond the term of the program. However, this could increase risks associated with project performance. To address this issue, policymakers can include a requirement that project developers maintain ownership for a specified number of years or forfeit a portion of the tax credit. An ownership requirement of five years is a key design element of the United States ITC, as highlighted in Text Box 7. Effective ITC design is critical as ITCs present specific challenges including a lack of incentive to maximize production and the potential for developers to inflate costs. Policymakers should carefully consider these potential challenges when choosing and designing tax credit policies.
- *Considering other incentives for self-generation and smaller-scale systems*—Production tax credits can increase costs by requiring metering upgrades and ongoing reporting. While PTCs can be effective for larger systems, the cost-effectiveness is often diminished for small generators designed for on-site use. In these cases, policymakers may choose to either use other incentives or make assumptions based on location and system design for projects below a certain size. Requiring system warranties from installers of eligible small systems can increase the projects likelihood of long-term success.

Further Approaches to Support Private Investment

Attracting significant private investment for solar deployment remains a challenge in many countries. High costs of finance, perceived and actual risk, and capacity constraints are some of the critical barriers to solar finance, particularly in developing countries. To address these barriers, policymakers are implementing a number of finance-enabling initiatives. Select examples are highlighted below.

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[12] Tax credit incentives can be costly, which represents one of the most widespread criticisms of this policy (Timilsina et al 2011).

Good Practices and Considerations

Text Box 8. Morocco: Reducing risk and leveraging expertise to catalyze deployment of concentrating solar power

To support CSP deployment, the Government of Morocco sought to demonstrate a successful utility-scale CSP project and business model to attract private investment. To achieve this objective, the government partnered with the Moroccan Agency for Solar Energy (MASEN), international financial institutions and donors, and private developers to build the Ouarzazate I CSP plant (Falconer and Frisari 2012). Through this program, MASEN coordinated a successful public-private partnership, working with all partners to establish loan requirements and reduce transaction costs. Costs were further reduced through participation of the government as an equity partner and international financial institutions, which decreased the cost of capital and mitigated overall investment risk for private developers. (Stadelmann et al. 2014). By reducing project risks, the partners were able to attract private developers to participate in the effort, resulting in a winning project bid that was 25% lower than original project cost projections, thus reducing the need for government subsidies. Ultimately, the project was successful in effectively spreading risk, with the public partners assuming much of the political, financial, and commercial risk and the private partners taking on the construction and performance risks (Frisari et al. 2013).

- *Demonstrating projects*—Demonstration projects can be used to improve domestic familiarity with solar technologies, and provide critical information on project costs, construction timelines, supply-chain issues, and grid integration considerations. To support demonstration projects, governments often pursue financing from development banks and other international finance sources that are willing to take on associated risks. Leveraging finance from multiple organizations is frequently necessary for utility-scale solar projects and requires substantial coordination, particularly in early stages. Text Box 8 highlights Morocco's experience leveraging public private partnerships to reduce risks associated with a large-scale solar demonstration project. The impacts of demonstration projects can be seen in several of the World Bank International Finance Corporation's (IFC) projects throughout the world. The IFC provides financing for initial renewable energy projects, often identifying and overcoming barriers (e.g., land title issues) in the process. The projects then act as templates for other renewable energy projects, encouraging private, commercial financing and eliminating the need for funding from development banks or other international finance sources. The IFC has successfully used demonstration projects to provide templates for renewable energy deployment in Chile, Jamaica, Mexico, and other countries. Through its experience, the IFC has learned that it is essential to finance commercial projects so that the model can be directly applied to other commercial projects. While funding government projects still results in deployment of renewable energy technologies, it does not provide a replicable model for other commercial projects (Whittaker 2015).
- *Reducing risk*—To reduce real or perceived risks associated with financing solar projects, governments can provide full or partial loan guarantees to lenders, effectively taking responsibility for the loan if the borrower defaults.[13] Loan guarantees result in a lower cost of

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[13] The United States has two loan guarantee programs for which renewables are or were eligible: the 1703 and 1705 loan guarantee programs. However, there is a much longer-term loan guarantee program through U.S. Department of Agriculture for rural renewable energy projects. For more information about this program, see www.rd.usda.gov/programs-services/rural-energy-america-program-renewable-energy-systems-energy-efficiency.

capital and therefore reduce project costs. As with other policies, the design of a loan guarantee program will depend on specific government objectives. Loan guarantees can be used to drive deployment over the long term by providing funding for multiple years and accepting applications on a recurring basis. Conversely, if the government's objective is to encourage rapid deployment, the program can be designed to provide a substantial amount of loan guarantees over a short period. To limit public costs and risks, loan guarantees can be designed to include rigorous requirements for all applicants, including data and analysis evidencing technical and financial viability of the project. Policymakers can also determine and clearly articulate types of technologies eligible for loan guarantees to provide clarity to applicants and reduce transaction costs associated with application review. When finance from private lenders is unavailable or constrained, provision of low-cost or long-term debt by national governments is one of the least expensive policies to support solar deployment (Stadelmann et al. 2014). Text Box 7 (above) describes key design elements of the U.S. solar loan guarantee program.

- *Reducing soft costs*—Solar soft costs are related to financing, installation, permitting, interconnection, transmission, and system design, and they represent a significant portion of solar cost overall.[14] Over the last few decades, policymakers have supported work to reduce these soft costs, particularly for residential and small commercial applications.[15] Effective approaches to reduce soft costs are country-specific, as related barriers (e.g., permitting and interconnection costs) vary significantly. However, policymakers can pursue the following activities to support soft cost reductions: conducting solar workforce training and certification to install technologies correctly and efficiently, streamlining permitting processes, and reducing barriers associated with interconnection (Mirmira et al. 2013). Additionally, financial soft costs can be reduced with policies such as loan guarantees and other favorable financing mechanisms.
- *Training lending institutions*—Domestic lenders in countries with a nascent solar industry often perceive solar technologies (or any technology with which they are unfamiliar) to be high-risk investments that require high rates of return for loans. Training domestic lenders on solar project finance can help build a sustainable domestic market for solar technologies. Training may highlight detailed examples of existing projects and feasibility studies in other countries, and it can include sample pro formas and other resources to assist lenders in assessing the financial strength of potential projects. In addition, policymakers may consider supporting technical assistance to financial institutions to provide more detailed consultation in relation to project viability assessments and considerations. In addition to offering specific financial training, providing a more general primer on solar technology can also be beneficial. Such a primer may include an overview of different technologies (e.g., PV versus CSP), proven technologies versus emerging technologies, solar terminology, local solar resource data and mapping, and examples of successful projects in countries with similar contexts.

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[14] For example, in the United States, 40% of the total cost of utility-scale PV is associated with soft costs. While total generation costs from utility-scale PV fell from $0.21/kWh USD to $0.11/kWh USD between 2010 and 2014, the soft costs fell from about $0.07/kWh USD to $0.05/kWh USD over the same period (Pierce 2014).

[15] Rickerson et al. (2014) provide an overview of policies to reduce soft costs for residential and small-scale solar technologies

Summary

Table 2 summarizes the good practices and considerations presented in this paper. The appendix provides resources that can be used to support the detailed design and implementation of policies to support solar deployment.

Table 2. Summary of Good Practices

Policy	Good Practice
Renewable electricity standards and solar set-asides	• Sending incremental and consistent policy signals to encourage gradual increases in solar deployment. • Setting appropriate and declining alternative compliance payment (ACP) rates • Designing solar-specific RECs to meet solar set-aside requirement • Establishing net metering and interconnection standards to complement solar RES; scaling up solar deployment requires development of multi-faceted policy packages • Considering project size, location, and land use.
Feed-in tariffs	• Linking solar FITs to high-level solar targets and a strong policy framework • Predictably and gradually decreasing solar FIT prices • Understanding the benefits and value of solar • Considering linkages with other policies.
Auctions/tendering processes	• Considering project size • Minimizing policy costs through effective design • Facilitating participation through providing transparent, timely, and consistent information • Ensuring developer experience and technical capability.
Net metering	• Ensuring inclusive eligibility • Setting appropriate capacity limits • Designing appropriate billing approaches • Considering aggregate net metering approaches.
Interconnection standards	• Designing a standardized interconnection policy • Ensuring comprehensive policy coverage • Setting appropriate capacity limits • Reducing administrative and application costs
Solar investment and production tax credits	• Establishing an appropriate incentive rate and controlling costs • Determining the tax incentive period • Considering other incentives for self-generation and smaller-scale systems.
Further approaches to support private investment	• Demonstrating projects • Reducing risk • Reducing soft costs • Training lending institutions.

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Appendix. Additional Support and Resources

Targeted technical assistance regarding the design and implementation of renewable energy polies is provided by:

- Clean Energy Solutions Center Ask an Expert—The Solutions Center Ask an Expert service is available at no cost to government agency representatives from any country and the technical institutes assisting them. If your request qualifies for assistance, you will be matched with the Solutions Center expert who is most qualified to help you, for up to 40 hours of assistance. For more information, see cleanenergysolutions.org/expert.
- Climate Technology Center & Network (CTCN)—Climate Technology Center & Network (CTCN)—The CTCN provides technical assistance in response to requests submitted by developing countries via their National Designated Entities (NDEs). Upon receipt of such requests, the CTC quickly mobilizes its global Network of climate technology experts to design and deliver a customized solution tailored to local needs. The CTCN does not provide funding directly to countries, but instead supports the provision of technical assistance provided by experts on specific climate technology sectors. For more information, see ctc-n.org/technical-assistance.

Additional resources—including good practice resources and publications, policy examples and databases, webinars and training resources, and a glossary—are available at cleanenergysolutions.org/policy-briefs/solar.