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# How do policies mobilize private finance for renewable energy?—A systematic review with an investor perspective

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## HIGHLIGHTS

- This study reviews the effectiveness of policies for renewable energy investments.
- We analyse the impact of policies on investment risk and investment return.
- We separate the effect of policy design elements on investment risk and return.
- The study has important policy implications for a privately financed energy transition.

## ARTICLE INFO

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## ABSTRACT

With the urgency of climate change, and billions spent globally on renewable energy (RE) support policies, it is crucial to understand which policies are effective. Substantial scholarly research on RE deployment policies has been carried out over the last two decades, resulting in inconclusive findings regarding the effectiveness of mobilizing private finance. Here, we take a novel perspective and review 96 empirical studies concerning the impact of policies on two key investor decision metrics: investment risk and investment return. Only if both metrics correspond to the investors' expectations are they willing to engage in RE projects. First, our rigorous literature review shows that effective policies address risk and return simultaneously. Second, we find that generic instrument design features, such as credibility and predictability (continuous evaluation and monitoring), considerably impact investment risk. A more focused analysis of the specific design elements of feed-in tariffs, auctions and renewable portfolio standards reveals that these instruments are most effective when they are designed in such a way that they reduce RE project risk while increasing return. We distil important implications for policymakers who aim to foster renewable energy and clean technologies more broadly.

## 1. Introduction

Most policymakers and scholars agree that keeping global warming 'well below' two degrees Celsius as specified by the Paris Agreement and the corresponding transition of the global economy will require large-scale private investment in renewable energy (RE) from a broad range of investors [1–3]. While private investment is critical for deployment [4], the academic debate over the last 20 years has mainly analysed RE deployment policies without explicitly considering investment decision metrics. Broadly speaking, empirical studies assessed policies regarding their effectiveness, efficiency and other socio-economic goals [5–8]. Within this scope, the question of whether quantity or price-based instruments are more effective or efficient has been at the centre [9–11]. From there, scholars embarked on a trajectory comparing effectiveness of individual instruments in different contexts [e.g. 12,13], as well as in large-scale country-level analyses [e.g. 14–16]. These studies reveal inconclusive results regarding which instruments to use. At the same time, we witnessed a surge in the implementation of policy instruments around the globe with around 80% of high- and upper-middle-income countries adopting RE support policies [17,18].

A separate stream of literature has discussed the relationship between risk and return of a project and its link to investor engagement in renewable energy projects [19–22]. Financial economists generally agree that risk and return are the fundamental determinants for private investors [23–25]. Policy instruments can therefore affect investors'

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behaviour by either reducing the risk of a RE project, increasing the return or both [26–28]. While the decision metrics of investors are well-known, systemic knowledge about the dedicated effect of RE policy on investors remains scarce [29–32]. To address this gap, we focus on the following research question, analysing existing empirical evidence: *How do RE support policies influence RE project investment risk and investment return?*

In a first step, we perform a review of the qualitative and quantitative empirical RE policy literature, focusing on the effect of 18 different instrument types on risk and return. This paper is the first review to systematically analyse RE policy support, such as fiscal and financial instruments, market-based instruments and regulations regarding their risk and return implications. One important finding that emerges from this literature review is that very effective instruments reduce the risk while increasing the return. We also find that beyond policy instrument types, the specific policy designs [see 33–35] have major implications on the investment decision metrics. In a second step, we therefore carry out an in-depth analysis of the design elements of the three most important instrument types previously identified: feed-in tariffs (FITs), auctions for power purchase agreements (PPAs) and renewable portfolio standards (RPSs). We find that—independent of instrument type—policy designs that reduce risks have a strong impact on investments. The empirical evidence gained through our review allows us to derive recommendations for policymakers.

The remainder of this paper is structured as follows: Section 2 introduces our analytical framework, which forms the basis for our methodology to assemble the literature base (Section 3). Section 4 describes the sample of empirical studies. While Section 5 reports the results of the review of policy instrument types, Section 6 reports the results on RE policy design options. Conclusions and policy implications are drawn in Section 7.

## 2. Investment decisions and the effects of policy instruments and designs

### 2.1. Altering the risk-return profile to catalyse RE investments

In professional investment decisions, expected return and the associated risk are the most important metrics when describing the attractiveness of investment opportunities such as RE projects [22]. Thereby, ‘risk’ is (implicitly) conceptualized as the effect of an unpredictable event on the project value, considering both the probability of possible events and their financial impact in the case that they materialise [36]. The finance literature has long established a positive relationship between investment risk and return in theory [37] and, more recently, empirically [23,24]. Especially in project-finance setups, which are particularly important for RE investments, higher project risks translate directly into higher required returns [38,39], because the only collateral available to financiers is the RE asset and its expected future cash flows [40]. In line with previous literature on renewable energy investment [19,20,22], we focus in this review on idiosyncratic risk (and not portfolio risk). Generally, infrastructure assets such as RE projects tend to exhibit lower market risk but higher idiosyncratic risk than other asset classes [41]. This detachment from market risks implies a portfolio diversification benefit from infrastructure investments per se. If an investor thus decides to invest in infrastructure, each project is evaluated based on its risk-return characteristics in order to make the investment

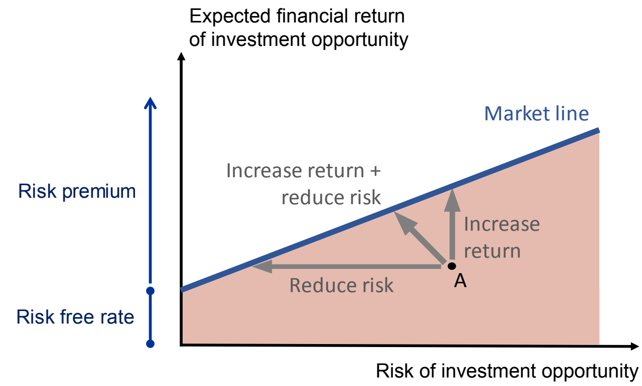


**Fig. 1.** A risk-return framework and policy options to attract investments.

decision. Therefore, the relevant unit of analysis remains the project, even though an investor may hold a portfolio. Fig. 1 shows a conceptual framework regarding the relationship of risk (x-axis) and expected return (y-axis), including a market line describing investment alternatives (blue line). With higher risks, an increasing risk premium is expected on top of the risk-free rate, often calculated as the yields of United States treasury bonds with a 30-day maturity [42]. When presented with an investment opportunity, a professional investor would go ahead and invest if a project reaches the market line but refrain if it is below the line (red area). The exact threshold would depend on individual investors’ preferences (e.g. risk aversion).

In order to make unattractive projects (e.g. A in Fig. 1) viable for investment, policy instruments can act in three ways: (i) increase the return (upward arrow), (ii) reduce the risk (leftward arrow) or (iii) a combination of the former and the latter (cf. [43,27]). Reducing risks, and thereby lowering the investment hurdle rate, is particularly important for RE investments due to their high upfront capital and resulting high financing requirements [26,27,44]. This review therefore uses the risk-return framework to classify empirical results. It does so by focusing on professional investors, because they account for 53% of global non-hydro renewable energy investments [45].

### 2.2. Policy instrument design

While the role of different instruments for inducing RE investment is discussed widely in the literature (see Section 5), design elements are poorly covered, with a few exceptions [46]. Innovation scholars have long been arguing that the effects of a policy do not only depend on the instrument type but also on its design [33,47–50]. For instance, a FIT for solar photovoltaic (PV) which exceeds the generation cost of that technology is more likely to result in a larger investment than one that is too low to compensate for all costs. More generally, public policy literature describes how any policy instrument can be understood as a composition of design elements [51]. While this literature analyses design features on three levels of abstraction [52], here we focus on the level of ‘on-the-ground-measures,’ which describe ‘settings’ (e.g. height of specific targets and target groups) and ‘calibrations’ (e.g. levels of subsidies). Although only a few papers exist which systematically analyse the role of policy design features on investment decisions, many empirical studies implicitly cover the role of design features.

Prior studies have focused on the distinction between policy effectiveness and economic efficiency [53,54]. The former generally refers to a substantial increase in deployment and investment. The latter emphasizes the fact that capacity should be generated at decreasing competitive cost due to learning but should also be considered from a societal point of view [55]. This includes a range of market failures and externalities as secondary policy goals, such as achieving technological improvements over time [56], generating employment [57], increasing actor diversity [58] or improving energy access [59,60]. In this paper, we focus on policy effectiveness, as existing evidence from empirical studies mainly refers to the question of whether policies lead to investment. Empirically establishing policy efficiency (i.e. also including societal policy cost and comparing it with alternatives) is beyond the scope of most empirical evidence so far. Based on the considerations in this section, we developed a methodology to assemble the literature base, which is discussed below.

## 3. Methodology

We conduct a systematic review of existing evidence to analyse how policy interventions mobilise private RE investors and specifically add the novel perspective on risk/return mechanisms for policy effectiveness. This article applies a semi-structured method, commonly used in the social sciences, to assemble the literature base [61–63]. It provides a more transparent, reliable and replicable way of selecting literature than the classical narrative review [64], while being less structured and more flexible than a meta-analysis [65]. It follows a sequence of steps searching for literature and applying inclusion and exclusion criteria guided by our analytical framework [cf. 61,66] (see Section 2.1).

Our semi-structured literature search is based on a 'Scopus' search using broad terms [67][1], existing reviews, empirical papers and a follow-up snow-balling of cited literature therein [68]. We screened abstracts of the resulting literature according to the scope of the literature review and included only those published peer-reviewed articles that were available (at least online-first) by August 2018. According to Hunter and Schmidt [65], this does not lead to an 'availability bias' for empirical studies if a sufficiently large article base is considered. In this case, the direction of the published and unpublished results tends to be similar.

We exclusively focus on empirical papers with primary (new) quantitative or qualitative data and/or analysis. Whereas quantitative studies provide a clear picture on effectiveness (size of effect), qualitative evidence is needed to understand the impact of policy instruments on RE investments via the risk and return factors. Geographically, only investment grade countries and the four BASIC emerging economies of Brazil, South Africa, India and China are considered in our analysis. Investment decisions in more risky (non-investment grade) countries are driven by very different factors (e.g. the involvement of development banks) [69,70]. This procedure, based on our inclusion criteria, resulted in a longlist of 135 articles.

Articles were then systematically analysed and the meta-data extracted [61,66]. A team of three independent researchers coded the literature and developed a comprehensive database containing information about findings (research question, key results, limitations/validity), method and scope (quantitative/qualitative/mixed, unit of analysis, data source, dependent variable, period under study and regional scope), technologies (e.g. wind onshore/offshore, solar PV, concentrated solar power [CSP]), instruments (e.g. FIT, investment credit, green certificates) and their impact on investment decision metrics (effects on investment, risk mitigation and return component). To ensure consistency of the coding and analysis process, the three coders frequently met and discussed potential ambiguities [cf. 61]. In case of disagreement between two coders, additional members of the research team were consulted.

From the longlist, we excluded papers that looked at drivers and barriers of RE in a general manner only, along with articles that did not implicitly or explicitly evaluate policy instruments. Lastly, we also excluded papers with an innovation (and not deployment/investment) focus to arrive at the final set of 96 articles. These articles are described in further detail in the next section.

[1] Scopus search 1: 'renewable energy deployment,' policy; Scopus search 2: 'renewable energy investment,' policy.

## 4. Overview of the identified literature

Two decades of research have produced a large and heterogeneous body of literature amounting to 35 qualitative, 57 quantitative and 4 mixed-methods papers (see Table 2 for a detailed overview of the instruments and their effects on risk and return). We differentiate these papers according to the paper's country scope and the empirical method applied. Two main types of analyses emerge: large-n comparisons, using regression techniques or other quantitative methods, and small-n comparisons or single-country studies using document-based or interview-based methods (see Fig. 2).

Concerning regional scope, the identified literature covers the European Union (EU) (44 articles), the United States (US) (19), the entire Organisation for Economic Co-operation and Development (OECD) (8), emerging economies (11) and global sets of countries (13). Studies of EU/US/OECD, as well as global studies using more aggregated policy measures, appear frequently amongst the large-n studies, most likely driven by data availability. Consistent with the expansion of RE capacity [17], most of the empirical articles subjected to this review were published between 2010 and 2018 (see Fig. 3).

Fig. 4 reveals that, in the empirical literature, most research articles cover onshore wind, followed by studies focusing on RE in general. Solar PV is analysed by significantly fewer articles, which might be due to the fact that solar PV technologies have only been deployed on a utility-scale since 2008–2010. Biomass and waste-to-energy (W2E) (23) and geothermal (14) have been analysed by over 10 studies and thus have been subject to substantial academic analysis. Other technologies, such as small hydro, have been covered only by a few studies. This corresponds to actual deployment and investment over the period from 2013 to 2016. Significant investment has also gone into offshore wind and concentrated solar power (CSP) projects (see right chart in Fig. 4). Thus far, the drivers of these investments have been analysed by very few academic papers.

Policy instruments that support RE can be categorized by several dimensions [29,71,72]. Here, we use a simplified version of the International Energy Agency (IEA) and International Renewable Energy Agency's (IRENA) Policies and Measures classification [73]. Compared to other classifications which consider the underlying economic logic of instruments [e.g. 74], the practice-oriented typology of IEA/IRENA seems more appropriate for our review from an investor's standpoint. Table 1 provides an overview of the classification and provides a definition for each instrument. While many instrument types directly support RE (e.g. direct investment or FITs), others increase the attractiveness of RE vis-à-vis fossil fuel-based power generation technologies by decreasing the revenues and/or increasing the risks of the latter (e.g. carbon tax or greenhouse gas [GHG] certificates).

FITs, tax credit/relief and auctions represent the most widely analysed economic policy measures, while scholars pay particular attention to quotas and RPSs. Other instruments, such as market-based instruments (carbon and green certificates) and direct public investment and support (information, long-term planning, RD&D), have played a subordinate role in empirical studies to date (see Fig. 5 for an overview).

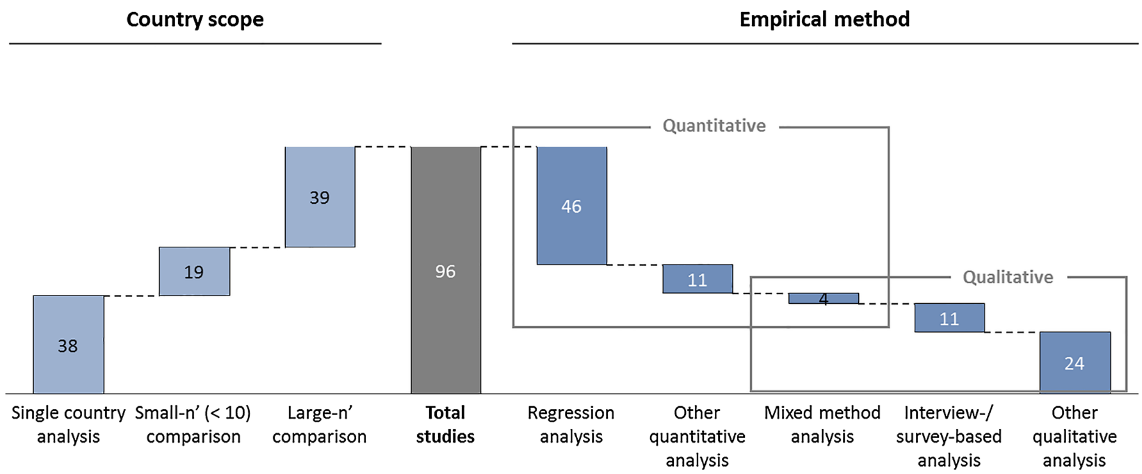


**Fig. 2.** Overview of research approaches.

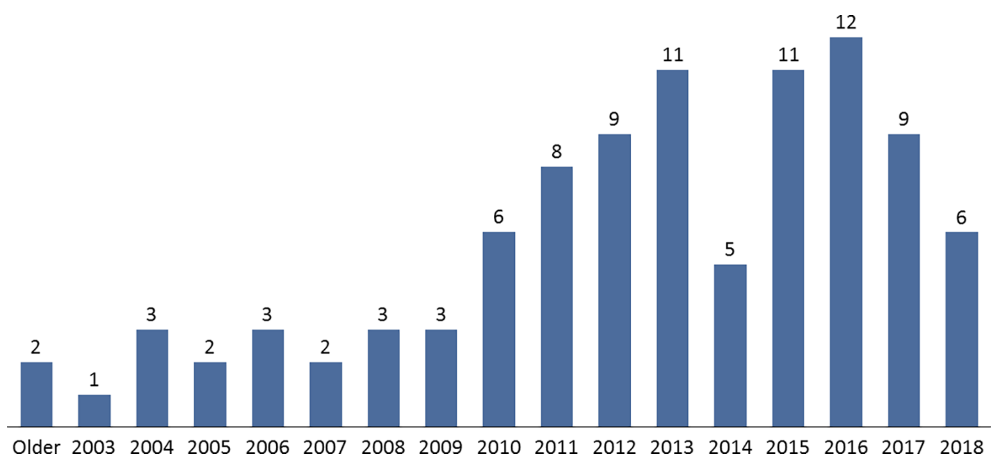


**Fig. 3.** Evolution of the literature publication dates. Note: Includes all studies in the scope of this article. No. for '2018' includes studies that were published until August 2018.

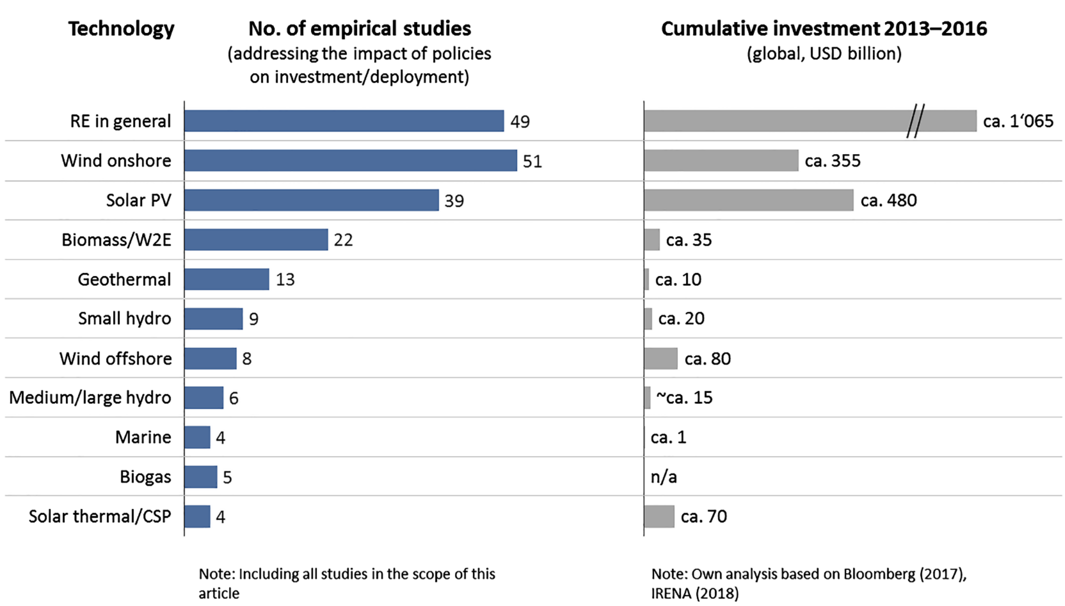


**Fig. 4.** Technologies covered with corresponding investment volumes.

**Table 1**
Taxonomy of instrument types with definitions.

| Category | Sub-category | Instrument | Definition |
|---|---|---|---|
| Economic instruments | | Public direct investment | Policies aimed at directly acquiring renewable power generation capacity by public authorities [cf. 75] |
| | Fiscal & financial | Feed-in tariff (FIT) | Policies offering a long-term agreement/regulation remunerating the sale of RE electricity at a fixed price which is typically above standard market levels [cf. 76] |
| | | Feed-in premium | Policies providing a premium on top of regular market prices for the sale of RE electricity [cf. 75] |
| | | Auction for PPA | Policies where public authorities organise tenders for a given quota of renewable supplies or capacity and remunerate winning bids at prices which are typically above standard market levels [cf. 75] |
| | | Production tax credit/relief | Provides the investor or owner of qualifying asset with an annual income tax credit based on the amount of energy generated during the relevant year [cf. 2] |
| | | Grants | Policies offering capital subsidies, consumer grants or rebates as one-time payments to cover a percentage of the capital cost of an RE investment [cf. 75] |
| | | Subsidized investment loans/funds | Policies providing ad hoc subsidised financing for investors [cf. 75] |
| | | Investment tax credit | Policies allowing for full or partial deduction from income tax obligations for investments in RE [cf. 75] |
| | | Guarantees | Policies offering guarantees for private RE investors, e.g. purchase guarantees to assure that all generated electricity will be bought [cf. 77] |
| | | Carbon tax | Tax on fossil fuels or carbon dioxide emissions intended to reduce the emission of carbon dioxide [cf. 76] |
| | Market-based | Carbon/GHG certificates | Policies introducing tradable carbon/GHG emission permits. Typically, the market size for these certificates is continuously being reduced (capped) [cf. 78] |
| | | Green certificates | Policies introducing tradable RE certificates representing the certified generation of units of RE, allowing the trading of RE obligations among consumers and/or producers [cf. 75] |
| Other instruments | Regulation | Quotas/RE portfolio standards | Quantity-based policy requiring companies to increase the amount of power generated by RE. The mechanism obligates utility companies to generate a specified share of their electricity by RE. Tradable RE certificates may or may not be a part of the instrument [cf. 76] |
| | | Net metering | Allows a two-way flow of electricity between the electricity distribution grid and customers with their own generation. The meter runs backwards when power is fed into the grid, with power compensated at the retail rate during the 'netting' cycle, regardless of whether instantaneous customer generation exceeds customer demand [cf. 2] |
| | | Tech standards | Policies imposing standards on actors requiring them to undertake specific measures and/or report on specific information [cf. 73] |
| | | Grid preference | Policies mandating that RE supplies are integrated into energy systems before supplies from other sources [cf. 2] |
| | Other | Long-term targets/ commitments | Steps in the ongoing process of developing, supporting and implementing policies, including targets and strategic plans, which guide policy development [cf. 73] |
| | | Research, development and demonstration (RD&D) | Policies providing research, development and deployment support, such as grants or tax breaks [cf. 31] |

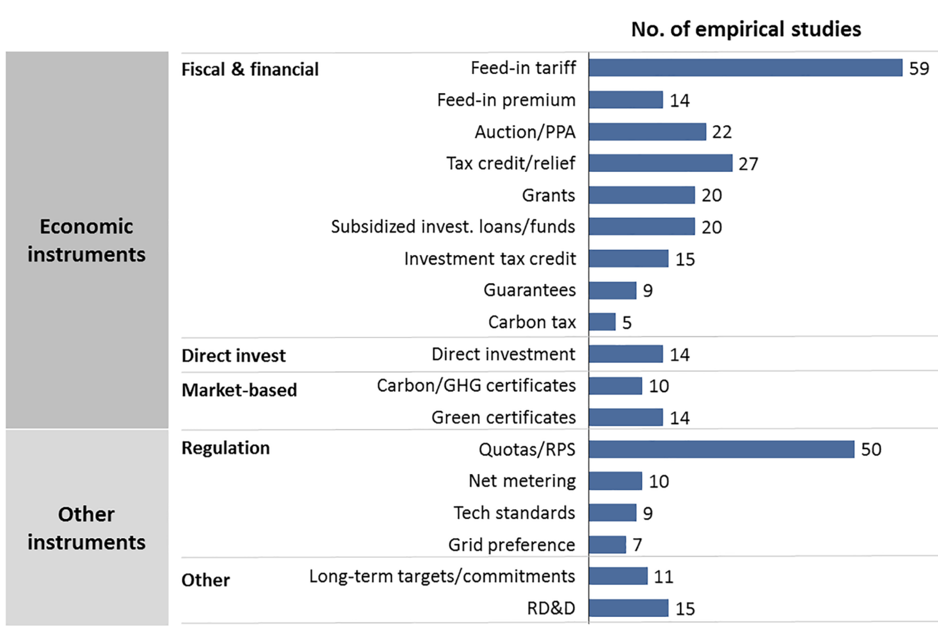


**Fig. 5.** Types of policy instruments.

## 5. Policy effectiveness through impact on risk and return of private investments

The empirical evidence concerning the effectiveness of different instruments, and particularly their impact on risk and return, is summarised in Table 2. In the following section we briefly describe the instruments' function and their most important impact channels on risk and return, using the four instrument sub-categories from Table 1. The narrative complements the tables by providing context on the actual use of different instruments, and by giving additional details concerning the evidence which is considered most important by the authors of this review.

**Table 2**
Policy effectiveness in inducing private investment through acting on risk and return.

| Policy instrument | | Overall instrument effectiveness[a] | Impact on risk | Impact on return |
|---|---|---|---|---|
| Public direct investment | | Limited mixed evidence | No direct effect; indirectly helping to build technology track record | No direct effect |
| Fiscal & financial | Feed-in tariff | Mostly positive evidence; larger effect compared to other instruments; more suitable for less mature technologies; risk of over-subsidizing, might attract broader range of investors | If properly implemented, more effective in risk reduction than any other instrument; removes price risk, volume risk and balancing risk (no specific load profile needed); creates policy risk of retroactive changes | Ensures stable return over a guaranteed period; support level influences investor return, with stability and predictability often seen as more important than level of remuneration |
| | Feed-in premium | Limited positive evidence; could do well in combination with FIT; attracts investment in areas that can produce in peak hours and incentivizes smart load management, which benefits system stability | Weak link between risk and premium; revenue stability is likely better for emerging techs and smaller investors | Support level influences investor return; additional component of premium should attract more investment in sites which can produce in peak hours |
| | Auction for PPA | Mostly positive evidence, even attracts early stage finance; can be used to reveal real prices and bring prices closer to effective cost; auction volumes high but realisation volumes low; tenders can lead to favouring large projects | Depends largely on design (e.g. support duration, required pre-bid planning, penalties), thereby failing to reduce risk (especially for small projects) | Positive effect through fixed price; depends on design, e.g. banding and pricing (uniform vs. pay-as-bid vs. vickery vs. median); stability and predictability often seen as more important than remuneration |
| | Production tax credit/relief | Mostly positive evidence | High policy uncertainty | Reduction of property tax and sales tax directly affect return of projects |
| | Grants | Mixed evidence, positive for residential | No direct effect | Temporarily reduces financing cost for residential |
| | Subsidized investment loans/funds and investment tax credit | Mixed evidence | Guarantees reduce risk and, hence, reduce cost of debt | Public loans and funds generate financial resources; capital grants and tax deductibility of investment costs affect returns |
| | Guarantees | Limited mixed evidence | Guarantees reduce risk | No direct effect |
| | Carbon tax | Limited positive evidence | No direct effect | RE generates returns by selling certificates; reduces returns from carbon dioxide emitters |
| Market-based | Carbon/GHG certificates | Limited mixed evidence | No direct effect | Potential to indirectly affect returns by increasing cost for competing technologies |
| | Green certificates | Mostly positive evidence; low social cost in the short term, but rather negative effect (on technology diversity, etc.) in the long term | No direct effect | Additional return from sale of 'green value' of generated electricity |
| Regulation | Quotas/RE portfolio standards | Mixed evidence, mostly positive; differences according to technologies; effectiveness lags behind FIT; usually delivers below targets; generally cost-effective | Associated with regulatory uncertainty (targets) but not easily retractable; do not mitigate risk (price, volume and balancing risks remain); more equity financing by large incumbent firms, but price negotiations critical; additional income risk | Leads to larger and more cost-effective projects than FIT; affects returns of utilities; FIT and RE obligations provide above-market returns (around same levels); RE obligations act as a premium on top of the negotiated off-taker price in the PPA |
| | Net-metering | Limited positive evidence, especially for solar PV (US); does not work in the absence of dedicated and small-scale financing lines | Financing lines do not come from private market because they perceive net-metering as too risky | Improves the rate of return |
| | Tech standards | Limited positive evidence | Reduction in technology variety decreases risk of incompatibility existing energy system and technologies | Reduction in technology variety reduces costs |
| | Grid preference | Limited positive evidence | In some geographical contexts, crucial for risk; guaranteed grid access | No direct effect |
| Other | Information & education | Limited positive evidence | Information is linked to social acceptance, which lowers risk; education in financial sector can decrease risk by improving project appraisal/structuring | No direct effect |
| | Long-term targets/ commitments | Positive evidence | Planning certainty is conducive to investments | No direct effect |
| | RD&D | Positive evidence | No direct effect | Reduces cost of developing/ improving technology |

[a] Limited evidence means that fewer than 10 papers cover the respective instrument.

### 5.1. Fiscal and financial instruments

**Direct investment:** Policymakers have the option to directly invest in a RE capacity [e.g. 14,29,71,79], for example, by using the vehicle of a green state investment bank [80]. While these investments do not directly mitigate risks for private co-investors, they can contribute to building a 'technology track record' and, thus, indirectly mitigate risks for the private sector [80].

**FITs:** FITs are the most widely implemented RE policy instrument globally, adopted by more than 80 countries by 2016 [17]. A large majority of the qualitative and quantitative studies associate the FIT with an increase in RE deployment and investment, and the effect is typically the largest of all the instruments, depending on the height of the tariff [e.g. 75,81–83]. A FIT reduces price risk for investors, as it guarantees a stable return over a specified period and caters well to the investors' need for predictable returns [31]. Consequently, FITs tend to lower financing costs [84]. Design elements, such as lead times, tariff durations, caps or grid connections, are often key success factors, as well [85,86] and are therefore discussed in detail in Section 6.

**Feed-in premiums:** There is less clear evidence for the effectiveness of feed-in premiums because they expose investors to the volatility of the electricity price to which the premium is linked [87–89]. While the effectiveness remains unclear, feed-in premiums create an incentive to balance the system and shave off peak load hours [87].

**Auction for PPA:** By 2016, around 30 countries worldwide adopted this support allocation mechanism [17], replacing FIT in some countries such as Germany [90]. Our reading of the evidence reveals mixed, but mostly positive, effects on RE deployment and investment [79,85,91–93]. Generally, auctioning volumes are good (i.e. high), but capacity additions usually remain below target because of the auction design [90]. The risk effect depends largely on design (e.g. support duration, required pre-bid planning and developer penalties) [94,95]. Similarly, the impact on return differs among designs (e.g. banding for specific technologies and auction pricing, contract standardisation and tariff caps) [18,90,94]. For a more elaborate discussion, see Section 6.

**Production tax credits and tax relief:** Approximately 40 countries worldwide include investment or production tax credits in their policy portfolio, and 100 countries reduce energy, sales, $CO_2$, VAT or other taxes [18]. We find mixed evidence for the effectiveness of production tax credits and reliefs [e.g. 96–100]. These instruments prove effective especially for biomass plants and wind turbine investments, as their generation costs have been historically closest to the market price and, hence, have the lowest profitability gap [92,97]. Property and sales tax incentives affect the return of RE investments. Generally, tax credits are associated with policy uncertainty since these directly depend on government budgets and changing fiscal decision making [101].

**Grants:** This basic form of RE support has been increasingly deployed over the last 10 years. Approximately 100 national jurisdictions feature public investment loans or grants [18]. The analysed literature reveals that grants can indeed spur RE deployment and investment. These forms of support are usually part of policy mixes including further fiscal and financial instruments such as FITs and tax breaks [71,72,102]. We find no direct effect on mitigating RE investment risk. Grants have been shown to have the greatest effect on increasing the return of a RE project in the residential segment by reducing upfront costs (not within the focus of this paper) in developed economies and, generally, in emerging economies [79,103,104].

**Subsidized investment loans/funds and investment tax credits:** These instruments, which feature prominently amongst energy policymakers, are weakly associated with mobilising private financial resources. Only a few studies find a positive effect [e.g. 72,102,105]. These investment-supporting instruments typically reduce the cost of debt (important especially for emerging economies), which increases equity investor returns. Tax deductibility of investment costs affects profitability [32], which is especially important for early-stage investors' return on equity [30,32].

**Guarantees:** In relation, studies provide some evidence that guarantees reduce risk for investors and, thus, accelerate the deployment of and investment in RE [e.g. 103,106,107]. Especially for novel technologies [79,80] and in emerging economies [27], this instrument has been proven to reduce risks. However, excessive loan guarantees for investors might lead to the funding of low quality projects and a resulting loss of investor confidence, which might explain part of the negative evidence [29].

**Carbon tax:** There is limited empirical support for the effects of explicit carbon pricing through a carbon tax. Eyraud et al. [31] found the strongest positive evidence, using RE investment microdata. Wall et al. [108] analysed the policy drivers for foreign direct investment (FDI) and found unanimous positive evidence. Other recent evidence is less clear-cut [109]. In a direct comparison of (fiscal) instruments, such as FITs or quotas by investors, the carbon tax is less preferred [30]. Interestingly, Pfeiffer and Mulder [91] found some effectiveness for $CO_2$ pricing mechanisms in Brazil, Russia, India, China and South Africa (BRICS). In general, a carbon tax is not considered to directly impact the risk of RE investments [30]; however, this instrument indirectly makes RE projects more attractive vis-à-vis their fossil fuel-based counterparts that are being affected. This is in line with one study which found that, to be effective, carbon taxes should be electricity-sector specific [109].

### 5.2. Market-based instruments

**Emission trading scheme (ETS):** Implementing a carbon emission cap-and-trade system (such as the EU ETS) to internalize the negative external effects of carbon emissions and induce low-carbon innovation and diffusion has been debated extensively among scholars [110–112]. Although theoretically optimal if stringently implemented globally, the direct empirical link between an ETS and RE deployment remains weak [76,111].

In the specific literature under consideration in this article, we find limited positive evidence for mobilising private finance and RE deployment [e.g. 29,76,113], especially as FDI in developing countries [108]. Even though it should have long-term implications if properly implemented, this is not reflected in our analysis due to the low prices of $CO_2$ certificates found globally, which, in turn, generate little incentives for individual investors [114]. At the same time, ETSs do not mitigate the risk of RE projects in light of investments in fossil fuel-based alternatives [13,29]. In some cases, mainly as a response to the newly induced risk (carbon price volatility), ETSs might lead to the postponing of RE investments [115]. Schmidt et al. [78] even found a perverse effect of ETS in inducing more coal rather than RE investment due to free allocations of emission certificates (grandfathering).

**Green (RE) certificates:** Another market-based instrument used in various countries is tradable green certificates for electricity produced from RE sources. Our analysis again reveals mixed evidence [e.g. 109,116–118]. Renewable energy certificates (RECs) depend strongly on (sub)national binding targets. We find only limited evidence linking the risks of RE projects to the development of green certificate markets [119].

### 5.3. Regulatory instruments

**RPSs or quotas:** RPSs and quotas have been employed in many jurisdictions and studied extensively [e.g. 120–125]. Approximately 100 jurisdictions worldwide, of which many are subnational states (e.g. in the US), introduced this instrument to support RE deployment [17]. The existing evidence is largely concentrated on the US [126] and the UK, with some additional insights from countries such as Sweden [127]. Generally, the use of RPSs/quotas is associated with the deployment of larger and more cost-effective projects owned by established companies and based on mature technologies, for example, landfill gas and wind onshore in the UK [128–131]. As they are mostly technology-neutral within the field of RE technologies [49], RPSs and quotas seem most effective when the underlying technologies are mature and potentially close to grid parity (for more details on technology-neutrality and other design features, see Section 6). RPSs often missed their stipulated deployment targets because price, volume and balancing risk remain, making revenues uncertain for investors [131,132]. Because RPSs favour mature (and more cost-effective) technologies, they tend to discourage the introduction of new technologies [122,133,134]. This is, in part, because the RPS does not mitigate revenue volatility (i.e. risk) and, therefore, favours incumbent firms with the capacity to finance projects on their balance sheet [135]. In emerging economies, technology-neutral quotas introduce additional income risk due to price competition among technologies and sites, as well as equity investors demanding a premium for it [85].

**Net-metering:** Net-metering, which has been adopted in more than 50 countries worldwide [17], often on a subnational level, has shown positive effects for the residential market [129,130], where it can improve the internal rate of return if dedicated financing lines are available. However, the investment size in this market segment is usually too small and risky for private financiers [101,120]. Consequently, Wall et al. [108] did not find an effect on attracting FDI. It would require the bundling of small projects into third-party ownership models, for example, through leasing them to house owners to attract professional investors [136].

**Technology and grid standards:** There are a number of technical regulatory instruments which have been studied in only a few papers. Standards such as grid codes, mandatory grid connection or reporting standards for produced electricity have been shown to only influence early stage investors [30]. They reduce the risk for technology incompatibility in the future and enable cost reduction by focusing on a limited set of technology specifications. Grid codes and grid preference, one of the design features of other instruments such as FITs, have proven to be important for reducing risks [27,85,137].

### 5.4. Other instruments

**Information and education:** These efforts can only indirectly influence private RE investments, for example, by establishing RE project evaluation standards in the investment community [80]. Allowing interest groups to take part in RE projects can increase social acceptance and decrease risk [138,139].

**Long-term targets/commitments**: Policy strategies such as long-term commitments (often operationalized through long-term targets) reveal mixed evidence, as they often depend on governmental credibility [29,72,140–142]. Trust in the future commitment of policy-makers indirectly reduces the risk of investors and is one of the most important generic policy design features. Long-term strategies are particularly credible when coupled with a broad, non-partisan alignment [143], such as the German energy transition after 2011.

**RD&D:** Research, development and demonstration measures indirectly influence investments in RE technologies by reducing technical risk and decreasing costs. We find mixed evidence in our sample, especially for less mature technologies such as solar PV [93,109]. In China, Li et al. [96] associated wind power capacity additions to state RD&D programs.

To sum up the current state of knowledge on policy effectiveness in inducing private RE investment through reducing risk and/or increasing returns, we find that FIT (also in the early stages of the technology lifecycle), quota mechanisms and auctions (especially for mature technologies) tend to be the most effective instruments when used alongside a credible RE planning framework. However, the analysis reveals that identical instrument types can produce very diverse results. Our reading of the evidence points out that one needs to go one layer deeper and analyse policy design to draw meaningful conclusions about policy impacts on risk, return and its effectiveness. We therefore dedicate the following section to exploring policy design features and consider their impact on risk and return.

## 6. Policy design as determining factor of policy effectiveness

The consolidated evidence from our review points towards an important role of policy design in altering the risk and return of RE projects. For example, Shrimali and Jenner [144], Carley et al. [126] and Kilinc-Ata [92] all mentioned weak policy design and low policy *stringency* as reasons for ineffectiveness. Although few papers explicitly consider policy design in their analyses, many discuss near expiry and frequent policy revisions in relation to increasing risk of RE projects [e.g. 98,140]. In terms of design features, this refers to policy *predictability*. On the one hand, retroactive changes to existing policy regimes or changing renewable energy targets have a negative impact on effectiveness by reducing returns [e.g. 92,140]. For example, RPS policies had a significantly smaller effect in states which previously passed and repealed electric utility industry restructuring legislation [135]. On the other hand, iterative policy adaptation that builds on knowledge from past policy schemes and following market development (e.g. from technology availability to financing availability to grid and counterparty risk mitigation) keeps policy costs down [13]. In this regard, continuous monitoring, evaluation and coordination between responsible government bodies increase policy *credibility* and reduce legal risk, which better addresses investors' needs [145,146], underlining the importance of formal institutions [19].

Scholars recommend well-designed, technology-specific and credible policy set-ups (e.g. avoiding confusion between R&D funding and deployment) to increase effectiveness [86,138]. Prior research also recommends that adjustments to policies should only apply to future contracts, the timing should be known in advance and reflect market conditions and changes should not happen too frequently [86,94,147]. Sufficient lead times between announcement and implementation ensure that firms can adjust their operations and strategy [148]. Handling compliance with policy instruments flexibly seems particularly important if the market is competitive and electricity providers are not very solvent, as is the case in an emerging market with new players. Policy stringency, with clear contracts, seems to be even more relevant if the market is vertically integrated, for example, if the market is dominated by incumbent utilities [148]. Also standardized (long-term) contracts reduce overall legal risks [94,147].

In addition to these *generic* design characteristics of policy instruments, we analyse the *specific* policy design features of FIT, auctions and RPSs, the three most frequently implemented and analysed policy instruments, and their impact on the risk and return of RE projects.

### 6.1. FITs

Most FITs differentiate support levels (i.e. the tariffs paid) by technology. Consequently, we did not identify an empirical analysis of the influence of *technology-specificity* on RE diffusion [46,49]. We focus on the main design elements of a FIT, which include the duration of the contract, tariff level, premium, cap and grid connection (Table 3).

*Tariff duration* significantly influences the effectiveness of a FIT policy, as it guarantees revenue streams [15,109]. Hence, duration determines the riskiness of a project; a long-term contract reduces risk, whereas variability in duration increases risk [93,147].

Although many studies find a positive effect from the *tariff level* on diffusion and investments of RE in general [82,149,150], other analyses differentiate this pattern according to technologies and type of investor [151,152]. For example, Cárdenas Rodríguez et al. [97] included the tariff level for wind and PV project investments globally and found a positive effect. However, excessively generous FITs, especially in the solar PV sector, discourage investments, as investors are concerned about the sustainability of such a regime [75,97].

A *fixed tariff* has been found to reduce or remove the price risk completely, therefore affecting the return on investment [82,153,154], whereas variability of the tariff structure increases uncertainty [82,93,154]. For example, when the German FIT was revised from a premium to a guaranteed price in 2000, it became evident that the FIT was valid irrespective of the timing and volume of electricity provided. These design parameters transferred price, as well as volume and balancing risk (through priority dispatch), away from the generator onto the grid operator [155]. If a FIT is implemented as a *premium,* it makes the policy less attractive than a fixed price, due to the remaining electricity price risk [147], but still positively

**Table 3**
Instrument design and effects on risk/return for FITs.

| | Effectiveness | Risk | Return |
|---|---|---|---|
| Duration | Contract duration and price have significant influence on the effectiveness of FIT [15] | Contract duration impacts risk [15,82,109]; long-term contracts reduce revenue risks [147]; variability of duration and cap increases uncertainty [93] | Tariffs weighted with the duration of PPAs have a positive effect on RE investments [109] |
| Tariff level | High tariffs might also negatively affect deployment [15,82]; excessively generous FITs tend to discourage investment [75,97]; only some models find positive effects from tariffs [150]; FIT stability is often mentioned, but changes do not distract investors [158] | More variability in tariff increases uncertainty [93]; FIT reduces/removes all risk [138,153] | FIT linked to return [82,149]; stability of regulation (volume and price) is important [154]; FIT based on generation cost instead of being value-based can mobilize investment [147] |
| Premium | Positive effect on ratio between the FIT and the retail electricity price [156] | Premium riskier than fixed FIT [147] | Premium component crucial for affecting return [153] |
| Cap | Negative evidence [93] | Cap of FIT can cause uncertainty amongst potential investors [93]; governing mechanisms should be clear [147] | Caps make policy cost more predictable and increase bidding competition, thus lowering price [82,94]; planned digression favourable [82,153] |
| Grid connection | Guaranteed grid access makes FIT effective [85] | Grid connections (swift grid access) and dispatch decrease risk [138,147,154]; anticipatory grid planning also reduces risk [157] | Low pass-through of interconnection fee affects return and increases deployment [157] |
| Design other | | Standard contracts decrease legal risks [94,147]; long-term contracts reduce revenue risks [147]; FITs that purchase less than 100% of the generated volume are riskier [147] | |

affects the return [153,156]. Also, those FITs that take into account on-site consumption are riskier because on-site consumption is typically not secured by a contract [147].

*Capping* a FIT can take two forms: policymakers could choose to limit the amount spent on RE electricity in total (*absolute cap*), or they could limit the price the ratepayer bears as a consequence of the FIT *(ratepayer impact cap)*. The absolute capacity eligible for a FIT reduces the total costs of the policy and increases the policy cost transparency with regard to the taxpayer [94]. However, such a cap induces significant risks and uncertainty in investors' calculations as it is unclear whether the individual project falls under the cap or not [93]. To mitigate these risks, transparency regarding the governing mechanism of caps is required. Also, absolute caps might be clearer than a ratepayer impact cap that may need to be translated into eligible capacity additions [147]. An alternative proposed in the literature is to plan the digression of the FIT ahead and make it adaptable in a predictable way [153], for example, it is suggested to base digression on the previous year's deployment, as shown by the flexible cap regulation in Germany since 2012 [143].

*Guaranteed grid connection* and dispatch have been found to be of the utmost importance for a successful FIT, reducing project risk [154], especially in emerging economies [85]. Lowering the pass-through of the interconnection cost of grid operators to project owners can further increase deployment by lowering the project costs [157].

### 6.2. *Auction for PPAs*

Together with its recently growing implementation, several design variants of auctions have emerged (see Table 4). These flexible deployment options include different contract durations, bidding

**Table 4**
Instrument design and effects on risk/return for auction for PPAs.

| | Effectiveness | Risk | Return |
|---|---|---|---|
| Duration | Needs to last long enough to be effective [139] | PPA duration a determinant of risk [109]; PPAs mitigate market risk (long-term contracts) [159] | |
| Price | Starting off with a high price can attract sufficient investment [94]; uniform pricing (and high competition) can lead to strategic (low) bidding and low realization; pay-as-bid is more robust against strategic bidding than uniform pricing [90] | Pricing/tariff mechanisms (e.g. guaranteed prices) address risk [159]; lowest price bids increase the concentration of RE power plants [139]; risks too high for new entrants [90] | Stable prices (i.e. revenues) are more important than the level of remuneration [94]; returns usually lower than FIT [90] |
| Banding | Banding makes the policy technology-specific [90], but it might result in administrative costs and low competition within bands [139] | | Many bands can lead to low competition per compartment (see effectiveness) and, thus, higher returns [139] |
| Set-up of bidding rounds | | Stop and go difficult for planning [139]; monitoring and evaluation is according to transparent criteria (risk) and requires secured debt pre-bidding to lower project risk [94] | Uniform set-up for all auctions favours industry learning and, hence, lowers financing costs [94] |
| Volume caps | | Caps make policy cost predictable and can, thus, make the policy more credible (especially in emerging economies) and lower risk [94] | Caps increase bidding competition and can, therefore, lower prices [94] |
| Contract specification | Penalty for non-performance or non-construction increases effectiveness [139]; no pre-bid building permit lowers realization rate; non-price selection criteria increase diversity [90] | Standardized contracts reduce risk [94]; penalties and pre-bid requirements increase risk, especially for small developers [90] | Penalties can also increase revenues by increasing risk and, thus, decreasing competition [90] |
| Technology specificity | Tech neutrality provides few opportunities for immature techs; [90] | | Highest profit for lowest cost technology results in low tech diversity; technology neutrality reduces revenues by increasing competition [90] |

processes and pricing, but regardless of the design options chosen, a uniform set-up for all auctions favours industry learning and, therefore, increases policy effectiveness [139].

The first determinant of policy effectiveness is the *duration of the PPA/contract*, which investors/project developers are bidding for. Longer durations reduce project and financing risks significantly as longer stable cash-flows are preferred by debt providers [109,159]. Second, the *pricing mechanisms* of an auction matter. Strategic bidding by the developers may result in construction delays or even projects being abandoned [139]. On the one hand, starting off with a high price seems necessary to attract sufficient investment [94]. On the other, selecting the lowest priced bids can increase the geographic concentration of RE power plants, as project developers build bigger installations to reach cost targets, therefore, increasing the likelihood of social resistance [139]. Mora et al. [90] explored the pricing dynamics in auction systems in 13 countries and found that uniform pricing (and high competition) can lead to strategic (low) bidding and low realization rates, as was the case in Spain. Finally, if an auction mechanism is used in combination with other policy support measures, it can be an efficient means to determine the required price, for example, the level of the FIT [77]. Additionally, streamlined planning procedures and low pre-auction requirements lower risk since they reduce legal complexity [139].

Scholars find that the risks of auctions might be too high for new entrants, as they typically incur higher financing costs and lack the advantage of 'economies of scale', which can be seen for example, in the context of Brazil [90]. Returns in auction mechanisms are usually lower than in a FIT, unless competition is very low because of design flaws. For example, in France, requirements for auctions were badly communicated; subsequently, most bids were invalid. In Denmark, very high penalties for offshore wind projects discouraged investors from bidding [90].

Moreover, research points out that *banding* assigns specific price-ranges and premiums to less mature technologies, as the price can be technology-specific. However, the excessive use of bands results in high administrative costs and low competition within the bands assuming the same overall number of investors (i.e. higher returns for investors) and, thus, lower effectiveness [90]. Technology-neutral auctions offer no chance for less mature technologies. However, a lower technological diversity also reduces the short-term (administrative) costs of the policy measure [90].

Auctions can also be arranged in *bidding rounds*, but sporadic stop and go, as well as a difficult planning process (e.g. pre-bid permissions), increases risk [139]. Organising the monitoring and evaluation of bidding rounds according to transparent predefined criteria can reduce risks. Requiring secured debt before entering the bidding process forces banks to use due diligence, therefore lowering project risk for (equity) investors in the project [94]. However, requiring additional pre-bid permissions increases the risk for project developers who have to invest to get the permission, as they may end up not getting the project [90,139].

Another design element of auctions is the *volume caps*. These make the policy cost predictable and the policy more credible as a result (especially in emerging economies), which lowers policy reversal risk. Caps also increase bidding competition and can, as a result, lower auction prices [94].

Finally, *contract specification* plays an important role in designing the auction mechanism. Including non-price selection criteria, such as social responsibility or actor diversity, can help to achieve policy goals other than deployment, as demonstrated in the case of South Africa [90]. The UK, for example, reduced the risk for small developers by limiting developers to only one awarded contract. In the Netherlands, small developers are exempt from pre-bid requirements [90].

### 6.3. Quotas/RE portfolio standards

Our literature review (Section 5) revealed that the effect of renewable portfolio standards (RPSs) on subsequent investments in RE capacity depends on the stringency and implemented design. Carley et al. [126] recently developed a measure for RPS stringency that encompasses the amount of renewable energy required over the number of years that policy is in place. They find that more stringency favours RE and solar PV generation. Interestingly, more stringent RPSs are not, however, conducive to more wind energy being generated.

RPS can be further customized in many ways, for example, by adjusting the duration of the contract, by defining capacity or sales requirements (including nominal vs. incremental capacity), by favouring less mature technologies that strategically use banding (price measure) or carve-outs (volume measure) or by introducing penalties. Other influencing factors include the percentage mandate, mandatory vs. voluntary RPSs and the number of years the policy has been present (see Table 5).

First of all, similar to FITs, *contract duration* plays a major role for the effectiveness of a RPS, as it signals policy stability [105] and, as a result, reduces policy risk. For example, an analysis of British RPSs revealed that short contract durations meant that RE producers and, consequently, investors would be undercut a few years down the road by new plants [12]. Governments that guarantee returns in a RPS contract if the utility fails to pay can be a remedy to this risk [126,144]. More recent evidence finds that RPS duration does not have an effect on wind capacity; therefore, RPS design might not impact investor confidence in this policy [15,126].

Second, scholars looked at the distinction between capacity requirements and sales requirements. Depending on the type of RPS, Shrimali and Kniefel [79] found different effects on the installed solar, wind and biomass capacity in the US. These results also depended on the specific RE policy in the respective US state. In both cases, guaranteed headroom between projected RE generation or sales and required certificates make certificate price collapses less likely and, therefore, reduce investment risk [131].

Third, studies distinguish between *nominal* required capacity in a RPS and *incremental* additions based on previous years [122]. Whereas some studies have found the former to be effective, especially in high-income countries [104], others found no effect [15]. In a direct comparison, those RPSs that require incremental capacity additions outperform those with nominal capacity requirements because these might already be met when the policy is introduced [122].

Fourth, assigning more certificates (for example via a multiplier) to certain technologies (*banding*) ensures technological diversity [105], reduces risk for corresponding investors and provides revenues [160]. Banding can thus help less mature technologies enter the market, attract investors [131] and avoid excessive subsidies for mature low-cost RE technologies [160]. Another possibility to deploy banding could be to set the multiplier rate (the relation between certificates and capacity) according to technologies by a government instead of by market participants [160].

Fifth, *carve-outs* mandate part of the RPS target be matched by defined (high-cost) technology, which allows for the entry of less mature RE technologies [160]. On the one hand, this design feature delivers a predictable number of certificates. On the other, it splits the RE certificate market, which might create liquidity issues, if there are low trade

**Table 5**
Instrument design and effects on risk/return for RPSs.

| | Effectiveness | Risk | Return |
|---|---|---|---|
| Duration | Purchase requirements must increase over time [148] | Policy duration uncertainty affects risk [161]; long-term contracts reduce risk of being undercut by new plants [12]; duration does not impact investor confidence [15] | Contracting mechanisms; state can provide guaranteed financial return for RE [129] |
| Capacity vs. sales | RPSs with capacity requirement conducive for geothermal, not for wind; RPSs with sales requirements conducive for solar and geothermal, not for RE in general or biomass plants [129] | Guaranteed headroom for capacity or sales between projected RE generation and required certificates reduces price risk [131] | |
| Nominal capacity vs. incremental capacity | Higher effectiveness for RPS than FIT for high-income countries [16]; quota award rate has no effect [15]; nominal RPS negatively correlated with share RE; incremental RPS positively correlated with share RE [122] | RPS mitigates risk (non-easily retractable measure) [29]; maximum effective retail rate increase (MERRI) after accounting for price caps of the penalty (alternative compliance payments) reduces risk [129] | |
| Banding (price measure) | Specific resource bands can help to diversify technology deployment [148] | Does not split up certificate market [160]; more certificates per megawatt hour (MWh) or different multiplier rates [160] for less mature technologies lowers the risk [131] | No over-subsidisation of low-cost technologies; drives RE cost reductions [160] |
| Carve-outs (volume measure) | Delivers predictable amount of RE [160] | Splits up certificate market (liquidity issues) [160]; creates boom and bust cycle if RE generation of a technology nears carve-out, and certificate prices will plummet [160] | Markets set differential among technology prices [160] |
| Penalties | Increase policy credibility [148] | Enforcement should be strict and clear (e.g. automatic financial penalties in case of non-compliance) [148] | |
| Design other | Number of years a RPS has been enacted positively influences utility share of RE investments of total investments (wind, solar) [121,126]; RPS that allows non-renewable energy generation negatively affect Solar generation and RE generation; RPS percentage mandate and mandatory increases share of RE, Solar generation and RE generation; RPS cost recovery increases share of RE, RE generation; RPS planning activities positively affects share of RE, Solar generation and RE generation; RPS geographical limits increase share of RE, Wind generation; REC markets positively affect Wind generation [126] | FIT for less than 5 Megawatts projects: smaller projects would seldom benefit from RPS, as the transaction costs and investment risks are too high [131] | Most cost-effective RPS solution, which reduces return for utilities [122] |

volumes, and may lead to a boom and bust cycle, if the carved-out capacity limit is approaching [160].

Sixth, scholars found that *penalties* for non-compliance with the RPS are only partially effective [126]. The scheme needs to be strictly enforced and in a timely manner in order to make the policy effective [148].

Finally, a recent mixed methods study by Carley et al. [126] included a range of other factors influencing the effectiveness, such as the percentage mandate, RPS mandatory policy, potential cost recovery for the utility and the number of years the policy has been present [see also 121,135]. Their study mostly found positive effects of an increase of RE and solar generation for many of these options. If trading of obligations is allowed, the additional exposure to the certificate market, with its multiple contracts and counterparties, introduces further risk. Higher RE targets and guaranteed headroom between projected RE generation and required RE capacity can reduce the risk of a price collapse and, therefore, increase investment [131]. In addition, Carley et al. [126] showed that tradability of generated certificates and the geographical limits in which they can be traded increases wind energy generation.

## 7. Conclusions and implications

### 7.1. Synthesis of the findings

In this paper, we set out to systematically review the empirical qualitative and quantitative literature on the influence of policy measures on RE deployment and investment. We specifically explored the mechanisms that link investment risk and return to the effectiveness of the instruments. We detected several interesting patterns that have received little attention hitherto. For instance, we observed that instruments that reduce risk and provide high certainty for investors are particularly effective in triggering private investment. Often, these instruments address the return metric as well. At the same time, our reading of the evidence suggested that the type of policy instrument only matters partially in the mobilisation of private finance for the deployment of RE technologies. Without paying special attention to policy design characteristics and implementation, which affect risks, policymakers and academics alike risk missing the *actual* determinants of effectiveness.

Our review of empirical literature underlines the high potential effectiveness of FITs and RPSs in attracting private investors, especially in comparison to other fiscal/financial, regulatory or market-based instrument types, such as carbon or green certificates. FIT performs better than any other instrument with regards to the introduction of new technologies. However, this comes at a cost, namely, uncertainty over the policy cost and a higher cost compared to a policy that always supports the marginally most cost-efficient technology. For all policy instruments, our review highlights credibility (no-retroactive changes) as a key design feature. In addition, continuous evaluation and monitoring to reflect market conditions minimises policy cost which also reduces the risk of (retroactive) policy dismantling. Additional aspects that might matter for policy credibility include how different instruments overlap to assure investors that their investments will remain profitable even if one of the instruments is removed [146].

The review of specific policy design options of FIT, auctions and RPSs reveals the fundamental trade-off between technology specificity offering favourable conditions (and higher returns) to less mature technologies and technology neutrality ensuring the deployment of the currently most cost-efficient technology. While the former increases technology diversity, it also increases the cost of the policy measure. If deployment/volume caps are introduced to ensure policy costs remain manageable, mechanisms and lead times should be transparently communicated to avoid negative effects on projected returns and calculated risks. Above all, standardized procedures and common design elements of policy instruments enable investors to gain experience more quickly and, consequently, reduce the risk in RE projects.

Our analysis of the empirical literature also emphasises the fact that many of the findings and results obtained are technology- and context-specific, which is in line with other analyses [e.g. 18]. Accordingly, more differentiated results, including the geographic scope of each respective study, are provided in Tables A.1 and A.2 in Appendix A.

### 7.2. Implications for policy

There are a number of policy implications generated from our work, and our study supports the decision-making process of policymakers in choosing instruments and design parameters.

In general, to ensure the effectiveness of policy instruments in attracting private investors, policymakers need to take the risk and return dimensions into account when considering the choice and the design of policy instruments. A first implication relates to technology-specificity, i.e. whether support levels are specific for different technologies. A high technology specificity seems to be particularly relevant for less mature technologies, which require higher *return* levels to compensate for the risk due to the missing track record. In other words, leaving the technology selection to the market will result in the most mature technology being selected. In order to avoid picking a technology with potentially low prospects, a portfolio approach focusing on several technologies can be taken. This, however, is likely to result in increased cost.

Second, the risk and return dimension should be taken into account also for policies supporting mature technologies, a status that solar PV and onshore wind have achieved in investment grade countries. Increasingly, policymakers move towards auctioned PPAs or market premiums for these technologies which require calibrations on many design parameters, as illustrated in this review. Explicitly considering the impact on risk and return of each parameter can help to design effective schemes and should likewise guide researchers who advise policymakers in that regard.

Third, reducing policy cost can be achieved through reducing *political risks*, which, in turn, lower financing cost. Policy predictability or stability is important in reducing risk. The basis for that seems to be a long-term strategy with a low risk of policy dismantling. At the same time, technological change requires some degree of flexibility in the policy, which must be adapted to falling RE cost. To avoid a trade-off between predictability and flexibility, policy adjustments should be announced early and be reasonable (i.e. reflect actual cost reductions). An alternative approach consists of 'adjustment rules' that specify under which (predetermined) conditions the government is allowed to deviate from existing policies [162]. There are ways to ensure that less mature RE technologies, such as solar PV (in the early 2000s), geothermal (in the early 2010s) or tidal (in 2018+), can be 'phased-in.' Design elements that favour such a phase-in include technology-specific FITs, RPSs with banding or carve-outs or auction regimes with technology-specific banding. Common to all instruments, international coordination would help to reduce technology costs more efficiently while maintaining stable electricity prices.

Finally, as renewables mature, a debate around phasing out support policies is emerging [163]. Our findings also have implications for this debate. Instead of completely abandoning policy support, which could deter investors, a gradual shift from more to less stringent policy designs seems more promising. Moving from one instrument type to another is also an option. Understanding investor decisions and risk perceptions will be crucial for policymakers in order to not lose private investment volumes when phasing out or shifting public support schemes.

### 7.3. Limitations and implications for research

This literature review specifically focuses on the implications of RE support policies (instrument choice and design features) for risk and return perceptions of RE investors in the deployment of RE. Avenues for future research broaden the scope of our research in five ways: First, this literature review provides the starting point for exploring more policy design options and their risk and return levers. Scholars could also disentangle the effects of instrument type and stringency, which this review has not done. Until now, measuring the stringency of a policy's instruments has proven a complex endeavour [126,135]. Second, subsequent research could broaden the spectrum of policy assessment, for example, by also considering private investments in energy efficient technologies or innovation. Third, scholars should explore the risk/return preferences of RE investors over time to verify some of the findings of this report and link them to conceptual or model evidence [164,165]. Fourth, in a response to potential unintended (or counteracting) consequences of different sets of policies, the policy mix literature stream [50,166,167] could be extended to include risk and return considerations. Finally, one should consider the socio-economic impacts of supporting different kinds of investors (professional, community, household, etc.), especially regarding inequality, energy justice or social acceptance [6,59,168,169].

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## Appendix A

**Table A1**
Policy influence on financing renewable energy (quantitative or mixed methods).

| Citation | Geogr. scope | Tech. scope | Economic instruments | | | | | | | | | | | | Other instruments | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Fiscal & financial instruments | | | | | | | | | Market-based Inst. | | DI | Regulations | | | | LTT | RD&D | Other |
| | | | FIT | FiP | Auct. | Tax cr. | Grant | Loan | ITC | Guar | C tax | ETS | GCE | | RPS | NM | TS | GP | | | |
| Polzin et al. [29] | OECD, 27 countries | RES | + | | | + | ● | ● | ● | ● | | + | ● | – | + | | | | + | | |
| | | Wind | + | | | ● | ● | ● | ● | ● | | + | ● | ● | + | | | | ● | | |
| | | PV | + | | | + | + | – | ● | ● | | – | – | – | + | | | | + | | |
| | | Bio | ● | | | ● | ● | ● | ● | ● | | ● | ● | ± | ● | | | | – | | |
| García-Álvarez [15] | EU, 28 countries | Wind | + | | | | | | | | | | | | ● | | | | | | |
| Ang, Röttgers and Burli [109] | OECD + G20, 46 countries | RES | + | ● | ● | | | | | | (+) | | ● | | | | | | | ● | |
| | | Wind | ● | ● | + | | | | | | ● | | + | | | | | | | + | |
| | | PV | + | ● | ● | | | | | | + | | + | | | | | | | – | |
| Romano et al. [32] | Global, 56 countries | RES | – | | | + | ● | ● | + | | | | + | ● | – | + | | | | | |
| Aguirre and Ibikunle [71] | EU, OECD, BRICS, 38 countries | RES | + | ● | ● | – | – | ● | ● | ● | | ● | ● | ● | ● | | | | | ● | |
| Cárdenas-Rodríguez et al. [97] | Global, 87 countries | RES | ± | | | ± | | | | | | | | | ± | | | | | ● | |
| | | Wind | (+) | | | (+) | | | | | | | | | (+) | | | | | ● | |
| | | PV | (+) | | | ● | | | | | | | | | – | | | | | ● | |
| | | Bio | + | | | (+) | | | | | | | | | ● | | | | | + | |
| | | SHP | – | | | ● | | | | | | | | | + | | | | | – | |
| Carley et al. [104] | Global, 164 countries | RES | (+) | | | | ● | | | | | | | | (+) | | | | ● | | |
| Eyraud et al. [31] | Global, 35 countries | RES | + | | | | | | | | + | + | | | ● | | | | | ● | |
| Nicolini and Tavoni [150] | FR, IT, GB, DE, ES | Wind, PV, Geo, SH, M/LHP | + | | | | | | | | | | – | | | | | | | | |
| Criscuolo and Menon [75] | OECD + EMDC, 29 countries | RES | ● | | + | | | | | | | | ● | | + | | | | | + | |
| | | Wind | + | | + | | | | | | | | ● | | + | | | | | + | |
| | | PV | ± | | + | | | | | | | | ● | | + | | | | | + | |
| Baldwin et al. [170] | Global, 149 countries | RES | + | | | | + | | | | | | | | + | | | | ● | | |
| Kim and Park [116] | Global, 30 countries | RES (Wind, PV, Bio, Geo) | + | | | | | | | | | | + | | | | | | | ● | |
| Bolkesjoe et al. [149] | EU, 5 countries | Wind | + | | ● | | | | | | | | | | ● | | | | | | |
| | | PV | + | | ● | | | | | | | | | | ● | | | | | | |
| | | Bio | ● | | ● | | | | | | | | | | + | | | | | | |
| Cumming et al. [171] | Industria-lized, 31 countries | RES | | | | | | | | | | | | | | | | | | | ± |
| Eleftheriadis and Anagnostopoulou [140] | GR | Wind | ● | | | ● | | | | | | | | | | | | ● | ● | | |
| | | PV | ● | | | ● | | | | | | | | | | | | ● | ● | | |
| Marques and Fuinhas [72] | EU, 23 countries | RES | + | + | + | + | + | + | + | + | | | | | | | | | ● | | |
| Marques and Fuinhas [142] | EU, 21 countries | RES | | | | | | | | | | | | | | | | | | | ± |
| Bird et al. [105] | US, 12 states | Wind | | | | + | + | + | + | | | | ● | | + | | | | ● | | |
| Delmas and Montes-Sancho [127] | US, 48 states | RES | | | | | | | | | | | | | ± | | | | | | |

(continued on next page)

**Table A1** (*continued*)

| Citation | Geogr. scope | Tech. scope | Economic instruments | | | | | | | | | | | | Other instruments | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Fiscal & financial instruments | | | | | | | | Market-based Inst. | | | DI | Regulations | | | | LTT | RD&D | Other |
| | | | FIT | FiP | Auct. | Tax cr. | Grant | Loan | ITC | Guar | C tax | ETS | GCE | | RPS | NM | TS | GP | | | |
| Johnstone et al. [107] | OECD, 25 countries | RES | ● | | | ● | + | + | + | + | | | ● | | | | | | | + | |
| | | Wind | – | | | ● | ● | ● | ● | ● | | | ● | | | | | | | + | |
| | | PV | + | | | ● | ● | ● | ● | ● | | | ● | | | | | | | + | |
| | | Bio | ● | | | ● | + | + | + | + | | | ● | | | | | | | ● | |
| | | Geo | ● | | | ● | + | + | + | + | | | ● | | | | | | | + | |
| | | Marine | ● | | | ● | ● | ● | ● | ● | | | ● | | | | | | | ● | |
| Menz and Vachon [124] | US, 39 states | Wind | | | | | | | | | | | | | + | | | | | | |
| Jenner et al. [82] | EU, 26 countries | Wind | + | ● | ● | ● | ● | | | | | | | | | | | | | | |
| | | PV | + | ● | ● | ● | ● | | | | | | | | | | | | | | |
| Popp et al. [151] | OECD, 26 countries | Wind | ● | | | | | | | | | | | | ● | | | | | | |
| | | Bio | + | | | | | | | | | | | | ● | | | | | | |
| Schmidt et al. [141] | EU, 7 countries | Other | | | | | | | | | | ± | | | | | | | | | |
| Schmidt et al. [78] | EU, 7 countries | Other | | | | | | | | | | ● | | | | | | | | | |
| Cansino et al. [99] | EU, 27 countries | RES | | | | ● | | | ● | | | | | | | | | | | | |
| Fabrizio [135] | US, 49 states | RES (Wind, PV, Bio, Geo, Other | | | | | | | | | | | | | ● | | | | | | |
| Pfeiffer and Mulder [91] | Global, 108 countries | RES (Wind, PV, Bio, Geo) | + | + | + | + | + | + | + | + | + | + | + | ● | + | + | + | + | – | | |
| Chang et al. [98] | Asia, 16 countries | RES | ● | ● | ● | ● | | ● | | | | | ● | ● | ● | ● | ● | | ● | ● | |
| Brunnschweiler [70] | Non-OECD, 119 countries | RES (Wind, PV, Geo, SHP, M/LHP) | | | | | | | | | | | | | | | | | | | +/- |
| Shen and Luo [103] | CN | RES (Wind, Solar, Bio, Other) | ● | ● | ● | ● | ● | ● | ● | ● | | | | ● | | | | ● | | | |
| Linnerud and Holden [117] | NO | SHP | | | | | | | | | | | ● | | | | | – | | | |
| | | MLHP | | | | | | | | | | | ● | | | | | | | | |
| Barradale [159] | US | Wind | | | – | – | | | ● | | | | | | | | | | | | |
| Kilinc-Ata [92] | EU, 27 countries + US, 50 states | RES | + | | + | + | | | | | | | | | ● | | | | | | |
| Shrimali et al. [129] | US, 51 states | RES | | | | | | ● | | | | | | | + | + | | | | | |
| Carley [161] | US, 39 states | RES | | | | | | | | | | | | | + | | | | | | |
| Shrimali and Jenner [144] | US, 16 states | PV | | | | + | + | | | | | | | | – | ● | ● | | | | |
| Shrimali and Kniefel [79] | US, 50 states | RES | | | ● | | + | | | | | | | ● | – | | | | | | |
| | | Wind | | | ● | | (+) | | | | | | | ● | (–) | | | | | | |
| | | PV | | | ● | | ● | | | | | | | ● | ● | | | | | | |
| | | Bio | | | ● | | + | | | | | | | ● | ± | | | | | | |
| | | Geo | | | ● | | (+) | | | | | | | ● | ● | | | | | | |
| Bürer and Wüstenhagen [30] | 60 principal or senior fund mangers | RES | + | | | ● | + | + | | | ● | ● | ● | | ● | | + | | | + | |
| del Río and Tarancon [81] | EU, 27 countries | Wind | + | | | | | | | | | | | | | | | | | | |
| Dong [133] | Global, 53 countries | Wind | + | | | | | | | | | | | | ● | | | | | | |
| Krasko and Doris [130] | US, 51 states | PV | | | | | | | | | | | | | + | + | | | | | |
| Li et al. [96] | EU, 21 countries | Wind | + | | | + | + | + | | | | | | | + | | | | | + | |
| | | PV | + | | | ● | ● | ● | | | | | | | ● | | | | | ● | |
| Sarzynski et al. [101] | US | PV | | | | + | + | | | | | | | | + | ● | | | | | |
| Schmid [125] | IN, 9 states | RES | ● | | | | | | | | | | | | + | | | | | | |
| Smith and Urpelainen [83] | Global, 26 countries | RES (Wind, PV, Bio, Geo) | + | | | | | | | | | | | | | | | | | | |
| Yin and Powers [122] | US, 50 states | RES | | | | | | ● | | | | | | | + | ● | | | | | |

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**Table A1** (*continued*)

| Citation | Geogr. scope | Tech. scope | Economic instruments | | | | | | | | | | | | Other instruments | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Fiscal & financial instruments | | | | | | | | | Market-based Inst. | | DI | Regulations | | | | LTT | RD&D | Other |
| | | | FIT | FiP | Auct. | Tax cr. | Grant | Loan | ITC | Guar | C tax | ETS | GCE | | RPS | NM | TS | GP | | | |
| Kahn [100] | US | Wind | | | | + | | | | | | | | | | | | | | | |
| Gavard [88] | DK | Wind | + | + | | | | | | | | | | | | | | | | | |
| Mulder [102] | EU, 15 countries | Wind | + | | | + | + | + | | | | | | | | | | | | | |
| Dijkgraaf et al. [93] | OECD, 30 countries | PV | + | | | | | | | | | | | | ● | | | | | ● | |
| Choi and Anadon [156] | OECD, 14 countries | PV | + | | | | | | | | | | | | + | | | | | ● | |
| Weigelt and Shittu [121] | 1542 firms | RES | | | | ● | | | | | | | | | + | | | | | | |
| | | Wind | | | | ● | | | | | | | | | + | | | | | | |
| | | PV | | | | ● | | | | | | | | | + | | | | | | |
| | | Bio | | | | ● | | | | | | | | | ● | | | | | | |
| Carley et al. [126] | US, 51 states | RES | | | | | | | | | | | | | + | | | | | | |
| | | Wind | | | | | | | | | | | | | – | | | | | | |
| | | PV | | | | | | | | | | | | | + | | | | | | |
| Wall et al. [108] | Global, 137 countries | RES | + | | + | + | ● | | – | | + | ● | ● | | ● | ● | | | | | + |
| | | Wind | + | | ● | ● | ● | | – | | + | + | ● | | + | ● | | | | | + |
| | | PV | + | | + | ● | ● | | + | | + | ● | ● | | + | ● | | | | | ● |
| | | Biomass | + | | ● | + | ● | | – | | + | ● | – | | ● | – | | | | | ● |
| Best and Burke [113] | EU, 28 countries + Global, 139 countries | Solar PV | + | | | | | | | | | + | | | | | | | | | + |
| | | Solar thermal | + | | | | | | | | | + | | | | | | | | | + |
| | | Wind | | | | | | | | | | + | – | | | | | | | | |

FIT = Feed-in-tariff, FiP = Feed-in-premium, Auct. = Auction/PPA, Tax cr. = Production tax credit/relief, Grant = Grants, Loan = Subsidized investment loan/funds, ITC = Investment tax credit, Guar = Guarantees, C tax = Carbon tax, ETS = Emission trading scheme, GCE = Green certificates, DI = Direct investment, RPS = Quotas/RE portfolio standards, NM = Net metering, TS = Technical Standards, GP = Grid Preference, LTT = Long-term targets/commitments, RD&D = Research Development and Demonstration, RES = Renewable Energy Systems in general, Wind = Onshore and Offshore Wind, PV = Photovoltaics, ST = Solar Thermal Energy, Bio = Biomass and Waste-to-Energy, Geo = Geothermal Energy, SHP = Small Hydro Power, M/LHP = Medium and Large Hydro Power, Marine = Marine Energy, Other = Other

+ = positive, - = negative, ± = positive and negative, ● = considered in paper, no instrument effect specified, [blank] = not considered in paper.

(*) = Paper does not (or sparsely) evaluate policy effects, but discusses design elements, circumstantial effects or others in detail.

**Table A2**
Policy influence on financing renewable energy (qualitative methods).

| Citation | Geogr. scope | Tech. scope | Economic instruments | | | | | | | | | | | | Other instruments | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Fiscal & financial instruments | | | | | | | | | Market-based Inst. | | DI | Regulations | | | | LTT | RD&D | Other |
| | | | FIT | FiP | Auct. | Tax cr. | Grant | Loan | ITC | Guar | C tax | ETS | GCE | | RPS | NM | TS | GP | | | |
| Friebe et al. [85] | EMDC | Wind | + | | ● | | | | ● | | | | | | ● | | | + | | | |
| Butler and Neuhoff [132] | GB, DE | Wind | + | | ● | | | | | | | | | | | | | | | | |
| Mitchell et al. [155] | DE, GB (England, Wales) | RES | + | + | | | | | | | | | | | (+) | | | | | | |
| Jacobsson and Lauber [167] (*) | DE | RES | ● | ● | | | | | | | | | | | ● | | ● | | ● | ● | |
| Mignon and Bergek [19] (*) | SE | RES | | | | | | | | | | | | | | | | | | | |
| Anadon and Surana [13] (*) | CN, IN | Wind | (+) | | | (+) | | | | | | | | + | (+) | | | | | | |
| Lipp [138] | DK, DE, GB | RES | + | | | | | | | | | | | | (+) | | | | | | |
| Mitchell and Connor [128] | GB | RES | | | | | | | | | | | | | (+) | | | | | | |
| Heiskanen et al. [152] | FI | Wind | + | | | | | | | | | | | | | | | | | | |
| | | PV | ● | | | | | | | | | | | | | | | | | | |
| | | Bio | ● | | | | | | | | | | | | | | | | | | |
| | | Geo | ● | | | | | | | | | | | | | | | | | | |
| | | Other | ● | | | | | | | | | | | | | | | | | | |
| Shrimali et al. [120] | IN | Wind | + | | | | | + | | | | (+) | | | | | | + | | | |
| | | PV | + | | | | | + | | | | (+) | | | | | | + | | | |
| Holburn [145] (*) | Ontario, Texas | RES | | | | | | | | | | | | | | | | | | | |
| Bergek and Jacobsson [134] | SE | RES | | | | | | | | | | | | | + | | | | | | |
| Menanteau et al. [9] | Europe | Wind | + | | | | | | | | | | | | (+) | | | | | | |
| Sovacool [137] | BE, CA, DK, FR, DE, JP, KR, PH, SG, ES, CH, GB, US | RES | + | | | ● | ● | ● | ● | | | | | | ● | ● | ● | ● | | ● | |
| Peña et al. [153] | PT | Wind | (+) | | | | | | | | | | | | | | | | | | |
| Becker and Fischer [77] | CN, IN, ZA | PV | ● | | ● | | | | | | | | | | | | | | | | |
| Leete et al. [118] | GB | Marine | | | | | | | | | | | | | (+) | | | | | | |
| del Río and Unruh [172] | ES | Wind | ● | ● | | | | | | | | | | | | | | | | | + |
| | | PV | + | ● | | | | | | | | | | | | | | | | | |
| Gutermuth [106] | DE | Wind | ● | + | | | ● | + | ● | ● | | | | | | | | | | | |
| | | PV | ● | (+) | | | + | ● | ● | ● | | | | | | | | | | | |
| | | Bio | ● | (+) | | | + | + | (+) | ● | | | | | | | | | | | |
| | | Geo | ● | ● | | | ● | + | ● | ● | | | | | | | | | | | |
| | | M/LHP | ● | + | | | ● | + | + | ● | | | | | | | | | | | |
| Jacobs et al. [147] (*) | Latin America and Caribbean | RES | ● | | | | | | | | | | | | | | | | | | |
| Yoon and Sim [86] (*) | KR | RES | ● | | | | | | | | | | | | ● | | | | | | |
| del Río and Gual [154] (*) | ES | Wind, PV, ST, Bio, SHP | ● | ● | | | | | | | | | | | | | | | | | |
| Fouquet and Johansson [158] | GB, DE | RES | + | | | | | | | | | | | | (+) | | | | | | |
| Alagappan et al. [157] | US | RES | + | | | | | | | | | | | | (+) | | | + | + | | |
| Eberhard and Kåberger [94] | ZA | Wind | ● | | + | | | | | | | | | | | | | | | | |
| | | PV | ● | | + | | | | | | | | | | | | | | | | |
| | | ST | ● | | + | | | | | | | | | | | | | | | | |
| | | Bio | ● | | ● | | | | | | | | | | | | | | | | |
| | | M/LHP | ● | | ● | | | | | | | | | | | | | | | | |
| Woodman and Mitchell [131] | GB | RES | | | | | | | | | | | | | (+) | | | | | | |

(continued on next page)

**Table A2** (*continued*)

| Citation | Geogr. scope | Tech. scope | Economic instruments | | | | | | | | | | | | | Other instruments | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Fiscal & financial instruments | | | | | | | | | Market-based Inst. | | DI | Regulations | | | | LTT | RD&D | Other |
| | | | FIT | FiP | Auct. | Tax cr. | Grant | Loan | ITC | Guar | C tax | ETS | GCE | | RPS | NM | TS | GP | | | |
| Schallenberg-Rodriguez and Haas [87] | ES | RES | ± | ± | | | | | | | | | | | | | | | | | |
| Buckman [160] (*) | GB, US | RES | | | | | | | | | | | | | ● | | | | | | |
| Wiser et al. [105] | US | RES | | | | | | | | | | | | | (+) | | | | | | |
| Lauber [12] | GB, DE, US | RES | + | | | | | | | | | | | | (+) | | | | | | |
| Del Río and Linares [139] (*) | IE, GB, FR, PT, CN, IN, CA (Quebec), BR, AR, UY, PE, ZA, MA) | RES | | | (+) | | | | | | | | | | | | | | | | |
| Aquila et al. [173] | BR | RES | (+) | | + | | | | | | | | | | | | ● | | | | |
| | | Wind | + | | + | | | | | | | | | | | | ● | | | | |
| | | PV | (+) | | (+) | | | | | | | | | | | | ● | | | | |
| | | Bio | ● | | ● | | | | | | | | | | | | ● | | | | |
| | | SHP | ● | | ● | | | | | | | | | | | | ● | | | | |
| Mora et al. [90] (*) | BR, CN, DK, FR, DE, IE, IT, NL, PT, ZA, ES, GB, US-CA | RES (PV, Wind, Bio | | | (+) | | | | | | | | | | | | | | | | |
| Geddes et al. [80] | DE, UK, AU | RES | | | | | | | (+) | (+) | | | | (+) | | | | | (+) | | |
| Haas et al. [46] | EU, 27 countries | RES (PV, Wind) | + | | (+) | (+) | | (+) | | | | (+) | | | (+) | | | | | | |
| Winkler et al. [95] | BR, FR, IT, NL, ZA | RES | | | ± | | | | | | | | | | | | | | | | |
| | | Wind | | | ± | | | | | | | | | | | | | | | | |
| | | PV | | | ± | | | | | | | | | | | | | | | | |
| | | Biomass | | | ± | | | | | | | | | | | | | | | | |

FIT = Feed-in-tariff, FiP = Feed-in-premium, Auct. = Auction/PPA, Tax cr. = Production tax credit/relief, Grant = Grants, Loan = Subsidized investment loan/funds, ITC = Investment tax credit, Guar = Guarantees, ETS = Emission trading scheme, GCE = Green certificates, DI = Direct investment, RPS = Quotas/RE portfolio standards, NM = Net metering, TS = Technical Standards, GP = Grid Preference, LTT = Long-term targets/commitments, RD&D = Research Development and Demonstration, RES = Renewable Energy Systems in general, Wind = Onshore and Offshore Wind, PV = Photovoltaics, ST = Solar Thermal Energy, Bio = Biomass and Waste-to-Energy, Geo = Geothermal Energy, SHP = Small Hydro Power, M/LHP = Medium and Large Hydro Power, Marine = Marine Energy, Other = Other

+ = positive, - = negative, ± = positive and negative, ● = considered in paper, no instrument effect specified, [blank] = not considered in paper.

(*) = Paper does not (or sparsely) evaluate policy effects, but discusses design elements, circumstantial effects or others in detail.

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