



University of Pennsylvania
ScholarlyCommons

Social Impact Research Experience (SIRE)

Wharton Undergraduate Research

2018

Policies for the Deployment of Renewable Energies: An Overview

Bernardo Sarti
University of Pennsylvania

Follow this and additional works at: <https://repository.upenn.edu/sire>

 Part of the [Business Commons](#), [Energy Policy Commons](#), [Environmental Policy Commons](#), and the [Environmental Studies Commons](#)

Sarti, Bernardo, "Policies for the Deployment of Renewable Energies: An Overview" (2018). *Social Impact Research Experience (SIRE)*. 62.
<https://repository.upenn.edu/sire/62>

This paper is posted at ScholarlyCommons. <https://repository.upenn.edu/sire/62>
For more information, please contact repository@pobox.upenn.edu.

Policies for the Deployment of Renewable Energies: An Overview

Abstract

This paper seeks to explore a comprehensive set of policy tools to promote the deployment of renewable energy capacity. Previous papers have mainly considered one or a handful of policy tools at a time, hence the literature lacks a clear taxonomy of available options to policymakers and the latest findings regarding their effectiveness. The main method of research has been secondary, in other words, literature review, with which I have designed a framework for the different available policies. Based on the findings of numerous studies, I recommend feed-in tariffs as the most effective policy tool in promoting renewable capacity additions at manageable costs. I also highlight the importance of combining investment based, operating support and consumer facing policies in a multi-faceted approach to renewable promotion.

Keywords

renewables, renewable energy, policy tools, policymaking, review

Disciplines

Business | Energy Policy | Environmental Policy | Environmental Studies

Policies for the Deployment of Renewable Energies: An Overview

Bernardo Sarti
Professor Sarah Light
The Wharton School

Abstract

This paper seeks to explore a comprehensive set of policy tools to promote the deployment of renewable energy capacity. Previous papers have mainly considered one or a handful of policy tools at a time, hence the literature lacks a clear taxonomy of available options to policymakers and the latest findings regarding their effectiveness. The main method of research has been secondary, in other words, literature review, with which I have designed a framework for the different available policies. Based on the findings of numerous studies, I recommend feed-in tariffs as the most effective policy tool in promoting renewable capacity additions at manageable costs. I also highlight the importance of combining investment based, operating support and consumer facing policies in a multi-faceted approach to renewable promotion.

Research Goal

Upon reviewing existing academic literature on renewable energy promotion policies, one is struck by the wide range of options available and the varying success of their implementation. While many papers have discussed specific policies or compared the effectiveness of some policies, few have attempted to describe and evaluate a comprehensive set of policy alternatives. Hence, in this paper, I assess not only investment and operational support policies but also consumer facing alternatives. By covering the full set of policy alternatives, I hope to provide a clear landscape of available options to policymakers and the latest findings regarding their effectiveness.

The goal of this paper is to establish the need for government intervention to promote renewable energy generation, provide an overview of the set of policies available to policymakers, explain what market failures they seek to address and evaluate their respective merits and pitfalls. Finally, I recommend feed-in tariffs as the most effective main support scheme in increasing overall renewable capacity in a timely manner. I also conclude that a comprehensive policy strategy that combines the best investment based, operating support and consumer facing policies will be the most successful.

To narrow the scope of the research, I will be drawing examples from policy implementations chiefly in the United States and the European Union and will devote more attention to direct renewable deployment policies (quotas, feed-in tariffs) rather than indirect policies (emissions cap).

Introduction

According to the Intergovernmental Panel on Climate Change's 5th Assessment Report (Summary for Policymakers),

Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. (...)

It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century.

As mankind grapples with how to best mitigate the impacts of anthropogenic climate change and thus avoid its more catastrophic consequences, reducing the carbon intensity of, or decarbonizing, our society's energy sources has emerged as a key priority. Electricity and Heat Production is the second largest contributing economic sector to greenhouse gas emissions (2010 levels), accounting for 28.4% of total emissions, just slightly behind Transportation (28.5%) (EPA). Increasingly, renewable energy sources, mainly wind, hydro and solar have become cost-effective and competitive vis-à-vis traditional high-carbon sources such as natural gas and coal (IPCC, 2013). Renewable energy already accounts for a majority of electricity-generating capacity additions and given the reduced costs and efficiencies that accompany scale, is one of the main, realistic mitigation levers at society's disposal. As such, the path to stabilizing world temperature increases goes through accelerated adoption of renewable energy.

Nonetheless, it must be said that decarbonizing electricity use on its own is not sufficient if we hope to curb global temperature increases below the 2C goal established by the Paris Agreement (Bodansky). The Electricity sector contributes over a quarter of the total greenhouse gas emissions, but significant emissions also come from the Industry, Transportation and

Agriculture sectors (IPCC, 2013). These sectors have less clear paths to full decarbonization either because of the inherent carbon intensity of certain activities (i.e. smelting and other industrial processes require combustion of petroleum and cannot be easily replaced with a renewable source) or the lack of scalable cost-effective solutions to current behavior (i.e. stagnant electric vehicle penetration) among other difficulties (Benjamin). Hence, the decarbonization of the electricity sector stands as a unique mitigation focus due to both its substantial contribution to emissions and the existence of broadly available, scalable and relatively cost-effective solutions to energy sources currently employed.

While there is evidence that market conditions and public opinion have made the deployment of renewable energy sources increasingly attractive to businesses, communities and governments, a number of imperfections and barriers to entry remain which prevent renewables from being widely adopted. Some of these challenges are existential, such as solar's inability to service base load energy demand given the intermittency of solar energy production on a given day, but several obstacles such as inadequate funding and monopolistic competition can be addressed through effective policy.

This paper will be structured in the following way. First, I will address how market failures plague the overall energy market, creating the need for policies to support the development of renewables. Then, I survey the myriad policy options available to government regulators at different levels of support – namely financing, operational or consumer-facing support for renewable energies. Finally, I argue that feed-in tariffs are the most effective principal support scheme to bolster the deployment of renewable energy. FITs are superior to other

options because they have been effective in demonstrably increasing renewable energy capacity while stimulating technological learning and controlling costs. However, no one policy should be considered sufficient on their own and comprehensive policy strategies are highly advised. Combining operational support policies such as FIT with favorable financing by way of soft loans or grants and consumer awareness initiatives like disclosure programs and green power options will likely yield the best results.

Policy Justification

Economists and other academics have remarked on the imperfections of the capitalist system of production for many decades. In economics, market failures describe situations in which the allocation of resources by a free market is inefficient and results in a loss of social welfare (Bator). Currently, the increased adoption of renewable energies is challenged by two distinct market failures – imperfect competition and negative externalities.

Imperfect competition is a type of market failure in which early market entrants (in this case, carbon intense energy producers) assume a monopolistic position after accruing scale and learning benefits over a period of time (Menanteau et al.). Monopolistic power, held by high carbon firms, disrupts the neoclassical tenet of efficient markets that mandates thoroughgoing competition (Solow). Renewable technologies, though progressing rapidly, still face a steep learning curve compared to entrenched coal and natural gas companies who have been able to build barriers to entry for many decades. Renewable energies face higher initial capital costs compared to conventional sources. Though they may be “cost competitive on a life-cycle basis, higher initial capital costs can mean that renewable energy provides less installed capacity per initial dollar invested than conventional energy sources” (Beck et al.). Renewable energies face a number of other barriers, including subsidies for competing fuels, higher transaction costs and fuel price risk all of which contribute to a less than level playing field (Beck et al.). As Menanteau et al. put it, “it is not because a particular technology is efficient that it is adopted, but rather because it is adopted that it will become efficient”. Hence, government has a role to play in ensuring renewables can compete in energy markets.

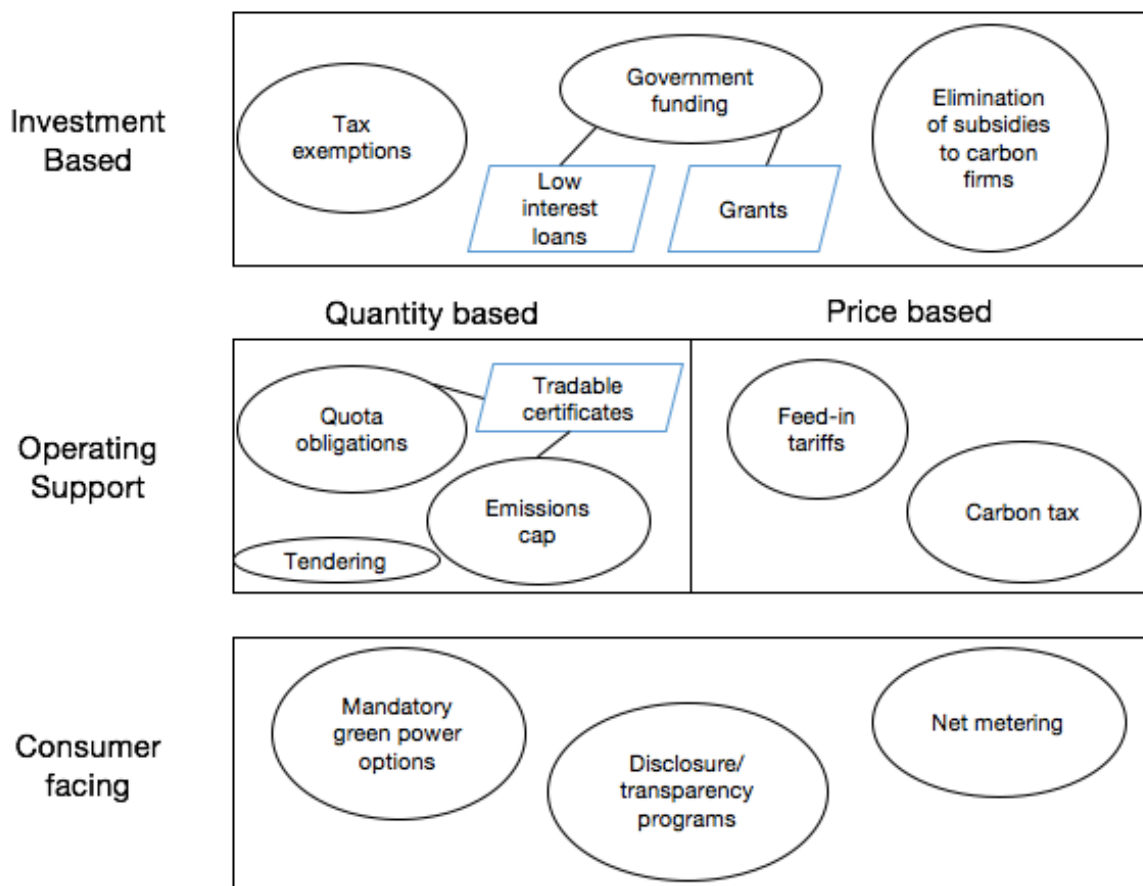
Negative externalities are a type of market failure in which an economic activity creates a negative side effect or cost borne by an unrelated third party (Library of Economics and Liberty). For instance, in the case of air pollution resulting from the emission of noxious gases by coal companies, the resulting cost to society (adverse health effects to name just one) is not incurred by either the producer or the consumer of coal-generated energy but instead by the entire society. Negative externalities have been identified as early as 1920 by British economist Arthur Cecil Pigou and are a hallmark concept in environmental economics (Library of Economics and Liberty). To achieve greater efficiency, society should internalize said externalities so that all parties are accountable to costs they are generating. The issue with the internalization of externalities is that the public goods which are often damaged by externalities (i.e. clean air) are non-rival (quantity not dependent on any individual user) and non-excludable (impossible to stop any one user from accessing good). Hence, private actors “are not prepared to invest in something which everyone can acquire free of charge” (Menanteau et al.). In many cases, negative externalities can be mitigated by better defining property rights but since goods such as clean air and global temperatures would be hard to delimitate and partition, they are better addressed by a government body.

The diffusion of renewable energies, thus, depends on government intervention to “protect them from direct competition with conventional technologies” and “correct negative externalities resulting from the use of fossil fuels” (Menanteau et al.). Government policy to spur renewables deployment can be justified as both a way to increase competition in the energy market (which benefits consumers by ultimately lowering prices) and preserve public goods such as climate stability and clean air.

Types of Policies

Upon surveying the literature on policy instruments meant to bolster the deployment of renewable energy, one is confronted with a dizzying array of policy options. To structure discussion of individual policies, I have subdivided existing policies into three categories: investment-based, operational support and consumer facing policies. The schematic below, though not exhaustive, illustrates the most commonly employed renewable energy promotion policies.

Figure 1: Renewable policy universe schematic



Investment based policies consist of tools governments can use to bolster the financial profile of renewable energy companies or reduce existing support for carbon intense firms. Tax exemptions and different forms of government funding (e.g. capital grants, low interest loans, public benefit funds) allow renewable energy companies to access and manage their capital more effectively. These policies can lower financial risk and encourage entrepreneurship in the renewable energy space by creating a more supportive investment outlook. Conversely, existing subsidies for conventional energy firms function as a barrier to entry and undermine the competitiveness of the energy market. Their elimination can be an important step forward in leveling the playing field for renewable energies and ensure fair competition. Notwithstanding, investment-based solutions are generally seen as less important than operating support (European Commission). They also remain understudied within the broader literature.

Operating support policies can be further subdivided into quantity-based and price-based approaches. Quantity mechanisms fix a certain production level of renewable electricity (quota obligations) or, inversely, cap a total level of greenhouse gas emissions (emissions cap) and are commonly accompanied by a system of tradable certificates in which firms who failed to meet a level of renewable electricity or greenhouse gas emissions trade with firms that exceeded their goals. It is important to note that an emissions cap is a broader policy mechanism that can cover emissions by economic sectors other than electricity generation, and thus bolster renewable energy sources only indirectly. Tendering is another quantity based instruments in which a “tender is announced for the provision of a certain amount of electricity from a certain technology source, and the bidding should ensure the cheapest offer is accepted” (European Commission). Price-based mechanisms fix a price to be paid for renewable electricity (feed-in

tariffs) or increase the price of conventional sources of energy by means of a carbon tax.

Exemption from broader carbon taxes to renewable energy firms also constitute a form of price based support. Price and quantity policy mechanisms have been deployed across the world and have been widely studied.

Consumer facing renewable energy policies include mainly, with the exception of net metering, policies that seek to change electricity consumers' behavior by providing them with additional options and information regarding their electricity sources. Mandatory green power options force utilities to offer customers the option to purchase all their electricity from renewable sources and thus, increase demand for renewable generation. Disclosure programs provide customers with a more detailed breakdown of where their electricity is being sourced with the goal of putting indirect pressure on utilities to green their fuel mix. Conversely, net metering allows customers with distributed generation to sell energy (most frequently solar) back to the grid, thus reducing overall demand for electricity. Consumer facing policies have been given uneven attention compared to the broader literature.

In the next sections, I will cover the mechanism, rationale and concerns associated with each of the policy tools. I will also discuss whether their implementation has been effective in increasing renewable energy generation. Since operational support policies often constitute governments' 'main' support scheme, I will cover them first, followed by investment based and consumer facing policies.

Operating support policies

Operating support policies target the internal business workings of energy firms meaning they directly affect the way energy firms conduct their operations. Operating support policies are usually the main support scheme used by governments to bolster renewable energies and are considered “far more important” than investment support (European Commission). Operational support is more instrumental to a renewable company’s fate since it has a more direct impact on profitability. There is however, significant disagreement over whether governments should adopt quantity based or price based operating policies. Quantity driven strategies target a desired level of renewable energy generation decided by the government, where the price is set by competition between generators. Under a quantity approach, policymakers set a desired quota or goal and a target date to encourage renewable energy penetration (Haas et al.). Price driven strategies set no quantity goals or targets and instead focus on providing support in terms of a “subsidy per kW of capacity installed or a payment per kWh of energy produced” (Haas et al.). According to economic theory, price and quantity based methods should yield the same impacts *ceteris paribus* (European Commission). However, “price-based and quantity-based approaches are not equivalent in situation where information is incomplete and where there is uncertainty” (Menanteau et al.). For instance, quantity based approaches rely, theoretically, on a government designation of the optimum level of renewable penetration which, in practice, is more debatable and uncertain. Price based approaches, on the other hand allow ultimate levels of penetration to fluctuate according to market pressures and may become fiscally onerous for governments. Therefore, the relative success of an approach versus the other depends on important contextual considerations.

Feed-in tariffs (FITs) are one of the main price-based operating support policies available. A feed-in tariff is “granted to operators of eligible domestic renewable electricity plants for the electricity they feed into the grid” and take the form of a “total price per unit of electricity paid to the producers” (European Commission). Feed-in tariffs operate as a subsidy allocated to producers of renewable electricity and function in the same way as a “pollution tax does for firms that pollute” but positively (Menanteau). FITs are the most widely used mechanism among EU member states (European Commission). Within the literature assessed, there is broad agreement that feed-in tariffs are successful in promoting renewable energy deployment. The European Commission points out that FITs “achieve greater renewable energy penetration, and do so at lower costs for consumers”. Menanteau et al. highlight the sustained wind development in Germany, Denmark and Spain as a result of FITs and that “price based approaches have given far better results than quantity based approaches” in terms of installed capacity. They claim the “attraction of fixed prices” and a “stable incentives framework” lead to predictable, safe investments (Menanteau et al.). The issue often raised when discussing FITs is the risk for government subsidies to become excessively onerous to governments, especially if the FIT is not designed dynamically. Haas et al. underscore the importance of intelligent FIT design to avoid the pitfalls of spiraling costs, these include “(i) a carefully calculated starting value; (ii) a dynamic decrease of the FIT that takes into account technological learning; (iii) the implementation of a stepped and technology-specific tariff structure”. FITs have to be structured degressively so that they “anticipate technical progress” and thus “more equitably reduce the total cost borne by the community while granting a certain surplus to producers” (Menanteau et al.). FITs strongly encourage technical learning through scale in capacity additions which in turn result in reduced prices for the community. The positive feedback loop makes FITs probably the

fastest and most effective catalyst of renewable deployment. Sovacool cites FIT experience in Canada and Germany as evidence that it is “is the best way to encourage quick expansion of renewable power”. Additionally, FITs were associated with substantial cost savings due to depressed overall electricity prices as well as impressive job creation (Sovacool).

Carbon taxes are another type of price based mechanism under which emissions intensive goods bear an increased cost or lower profit margin due to taxation and market forces result in an overall reduction in the quantity of emissions (Baranzini et al.). Carbon taxes are a form of Pigovian tax which internalize externalities created by polluting activities by forcing one of the parties to bear the cost that otherwise would be borne by society (Library of Economics and Liberty). Revenues generated by the tax can be reinvested in further climate mitigation or alternative energy sources. In a sense, carbon taxes are the primordial policy tool to correct the externality of climate stability. However, in practice, “taxes are faced with the problem of political acceptability and, furthermore, an environmental tax may not be sufficient in itself to stimulate the dynamic learning process required to bring down costs” for renewable energies (Menanteau et al.). Carbon taxes have not been widely implemented and there are several negative concerns regarding its distributional effects (Baranzini et al.). A carbon tax would certainly address the market failure of externalities but it lacks a mechanism to lower overall electricity costs rendering it unattractive to most governments and end users.

Quota obligations are one of the main quantity based operating policies used and are often implemented under the guise of Renewable Portfolio Standards (RPS). Renewable portfolio standards require electricity providers to “source an increase in amount of renewable energy in a

specified timeframe” (i.e. Oregon requires large utilities to source 25% of their electricity from renewable sources by 2025) by “generating electricity from renewable resources themselves, and/or exchanging renewable energy credits (RECs) or renewable energy certificates” (Delmas and Monte-Sancho). RPS targets can be measured in absolute units or as a percentage of total generation. RPS targets have been set on an EU-wide level (with states being free to pass more aggressive targets) and by over 25 US states. A literature review of RPS indicates mixed results regarding its effectiveness. Yi and Feiock point out that RPS is advocated by many as an effective policy instrument but note that allowing states to trade renewable energy certificates would “disincentivize renewable development in a state”. Yet in the same paper, they find that RPS is a positive and highly statistically significant predictor of increased renewable capacity under three comprehensive and contextualized modeling scenarios (Yi and Feiock). Conversely, Delmas and Monte Sancho point out that in most US states, RPS “did not have strong enforcement mechanisms” and there is no record of penalties paid for non-compliance in the US. They insist that policymakers are rewarded with political capital by imposing seemingly stringent standards but do not have the incentive to follow through with enforcement (Delmas and Monte Sancho). In their contextualized model, RPS proved to have a negative effect in renewable energy capacity investments. Shrimali and Kniefel also found RPS to have a negative impact on total renewable capacity ratio. Some reasons researchers have posited for the adverse impact of RPS include unambitious targets, lack of incremental adjustments, weak enforcement and differentiated responses from investor owned versus publicly owned utilities. In sum, RPS has been found to be increasingly insignificant in the promotion of renewable energy despite its widespread adoption. Though it may be effective under specific contexts, it generally leaves something to be desired due to its aspirational as opposed to hands-on support.

Tendering is a quantity-based mechanism. Under a tendering scheme, “a tender is announced for the provision of a certain amount of electricity from a certain technology source, and the bidding should ensure the cheapest offer is accepted” (EU Commission). Tendering has generally been employed in the EU with regard to offshore wind projects. Since tendering requires the government to be in possession of a mandate over a resource, its use is more limited than other policies and has been less studied. According to a historical review of EU renewable energy strategies, Haas et al. found that tendering schemes were largely abandoned after the 2000s due to their “poor effectiveness”. Menanteau et al. point out that bidding schemes leave producers with very tight margins thus limiting R&D investment and learning, which in turn jeopardize the long-term viability of the support scheme. It is worth noting that both tendering and RPS are policy schemes which allow governments to have greater control over their costs and thus avoid being overburdened by subsidy payments. For that reason, quantity based operating policies persist despite their disputed effectiveness.

Investment based policies

Investment based policies are policies which ease the process of financing operation of energy firms by either relaxing access to capital or reducing their tax liabilities. Investment based policies address the significant barriers to entry that exist for renewable energy sources versus their conventional energy competitors. In many cases, renewable energies do not dispose of robust access to capital markets, favorable tax treatment or long term investment certainty which would bolster their deployment. Financial incentives were the most common form of renewable energy policy in the early 1980s and were particularly effective in Denmark and Germany with regards to wind power (Haas et al.). Nowadays, investment based policies are seen mostly as a supplemental support scheme along with operational support (European Commission).

Tax exemptions or credits increase the attractiveness of renewable energy investments by mitigating the overall tax burden faced by producers or consumers. Tax credits may take the form of investment tax credits (ITCs), accelerated depreciation, production tax credits, pollution tax exemptions or personal income tax incentives (Beck et al.). These various policies act to encourage investors, producers and consumers to adopt renewable energies in order to obtain more favorable tax treatment. Tax incentives have been adopted as the main policy mechanism in some EU states (such as Sweden and Finland) generally used as a supplementary instrument. The effectiveness of “fiscal incentives depends on the applicable tax rate - in the Nordic countries, which apply high energy taxes, these tax exemptions can be sufficient to stimulate the use of renewable electricity; in countries with lower energy tax rates, they need to be accompanied by other measures” (European Commission). Sixteen US states employed income tax credits for solar and wind investments or the use of green electricity but these were found to

be insignificant predictors of increased capacity in a multivariate model conceived by Delmas and Monte-Sancho. Though appealing in theory, tax exemptions may be too indirect of a policy mechanism to spur the capacity additions policymakers seek.

Government financing of renewable energy firms through loans and grants can bolster deployment by offering a more reliable and cheap source of funding vis-à-vis less reliable capital markets. Low-interest, long term loans (also known as soft loans) are frequently unavailable to renewable technologies, thus exposing them to substantial financial risk. When governments step in to finance renewable energy developments, there is greater certainty regarding capital spend and long-term project funding. Soft loans have been implemented in several EU states such as Denmark and Germany. However, like other investment based policies, without operational support these mechanisms “have been found to play a supplemental role to other policies” (Lewis and Wiser). Commonly investment subsidies or soft loans are used “in addition to the main support scheme, such as feed-in tariffs or quota obligations” and due to their supplementary nature, their effectiveness is “difficult to measure” (European Commission). Despite this, soft loans can help make investments in renewable energy more attractive to investors and thus can contribute to a comprehensive renewables strategy by governments.

Despite their mature stage of industrial development and adverse environmental effects, conventional energy companies are still often heavily subsidized by governments. In the 1990s (and largely to this day), governments around the world “were handing out \$250–300 billion annually to subsidize fossil fuels and nuclear power” (Sawin and Flavin). The US provides one

of the more shocking examples with 90% of federal energy subsidies over the past six decades going to conventional sources. Additionally, “end-use energy efficiency has received only \$1 worth of subsidies for every \$35 spent on forms of conventional supply” (Sovacool). Conventional energy subsidies can take the form of budgetary transfers, R&D spending, tax incentives among others and result in “significantly lower final energy prices, putting renewable energy at a competitive disadvantage if it does not enjoy equally large subsidies” (Beck et al.). These subsidies distort electricity markets and competition in a variety of ways and their elimination would lead to several desirable results. Firstly, the removal of subsidies sends market signals that encourage consumers to use electricity rationally, seek out cleaner alternatives and avoid overconsumption. Moreover, the elimination of subsidies “would improve competition in the electricity industry, eliminating the unfair advantage given to nuclear and fossil-fuel technologies” and free up billions of dollars that can be spent on R&D and renewable technologies (Sovacool). Evidently, the elimination of conventional subsidies is highly contentious given the powerful carbon lobby but it is the most consistently cited preferred policy mechanism (72% of respondents) in a survey of 181 electricity sector stakeholders conducted by Sovacool. Conventional energy subsidies are a clear example of how governments play a role in upholding barriers to entry in the electricity sector. If the goal is to have thoroughgoing competition and cleaner energy, they must become a relic of the past.

Consumer facing policies

In addition to policies targeting electricity producers, there are a host of consumer-facing policies which can significantly increase the penetration of renewables. As public support for renewables builds, policies that raise the awareness and increase options of electricity consumers can help renewables realize their potential. Many of these policies also encourage rational electricity use and decrease overconsumption, which results in depressed electricity demand. Though perhaps not as immediately compelling or forceful as aforementioned policies, consumer mechanisms leverage societal attitudes and human behavior to reduce wasteful consumption and demand for conventional sources.

Mandatory green power options (MGPO) requires “electricity suppliers to provide an option for their customers to purchase green power either directly from their electric company or from an alternative provider” (Delmas and Monte-Sancho). Electric utilities can create this optionality by either generating green power themselves, purchasing it from a separate producer or buying renewable energy credits from their governing body. MGPOs place the burden of choice in the hands of consumers. The policy rationale follows that increasingly environmentally-minded consumers will opt to purchase green power, even if at a premium, thus increasing demand for renewables at the utility level and leading to increased renewables capacity additions. Yi and Feiock found in their study that green power options were a substantial predictor of increased renewable capacity ratio under three different modeling scenarios. Additionally, Delmas and Monte-Sancho showed that MGPO are effective in increasing installed renewable capacity and that market mechanisms which rely on “customer’s ability to purchase green power” can be very influential. MGPO are also an attractive mechanism for governments since they are a low-cost,

easy to implement policy that relies on organic demand for renewable sources. In a world where companies are increasingly eager to tout their green credibility and in which environmental consciousness plays a larger role in purchase decisions, MGPO are an obvious policy tool to bolster renewables spontaneously.

Disclosure programs require utilities to inform customers of what fuel sources they have used to produce the electricity served to their customers. The rationale behind disclosure programs is that they will lead to more thoughtful consumption and decision-making by consumers even though the policy itself does not provide a direct mechanism for reduced use of conventional sources. Studies have shown that disclosure programs have a positive effect on utilities' generation mix and consumers' willingness to pay for green power (Li and Feiock). Hence, despite lacking a mechanism for enforcement, disclosure programs place indirect pressure on producers and consumers to turn towards greener electricity fuel sources.

Net metering is a mechanism by which consumers with installed distributed generation (most often roof solar) are able to sell excess electricity back into the grid. The rationale for the policy follows that consumers have a financial incentive to install renewable generation in their homes and consume less than their total needs. In theory, net metering would lead to depressed demand and additional supply for the utility. In practice, however, net metering incentives have been found to be too insignificant to be effective and negatively associated with increases in renewable capacity (Li and Feiock). The reasons for this may be that distributed generation and metering are still too early in the adoption curve to be economically efficient or increased additions in distributed renewable may result in diminished utility-scale renewable additions.

Conclusion

As policymakers consider what policy they can implement to achieve the greatest increase in renewable capacity, there is a clear option which balances robust additions with cost management and dynamic learning. Feed-in tariffs meet all of these criteria and have been successfully implemented in several countries. FITs also have the benefit of producing results in a short period of time since as has been the case in Spain's experimentation with FIT (Haas et al.). Concerns about FIT are usually centered on whether it allows for too much producer profit which come at a cost to governments. These concerns can be addressed by thoughtful design which anticipates reduction in the renewable energy's marginal cost following technological and learning progress. As firms learn and become more efficient producers, governments gradually decrease their subsidy (Spain for instance discontinued FITs after a decade of implementation). For these reasons, I recommend feed-in tariffs as the preferred policy mechanism for renewables deployment.

It is important to note that very few of the policies discussed are direct substitutes to each other and, in fact, many should be pursued in tandem. Sovacool underscores the "necessity of comprehensiveness" in renewables promotion strategy arguing that "No single-policy mechanism is a panacea, and until comprehensive policy changes are implemented, renewable energy and energy efficiency will never realize their full potential". Even if feed-in tariffs are implemented, there is still a need to educate and encourage renewable energy consumers (through green power options and disclosure program) as well as favorable financing (through grants and soft loans). Furthermore, conventional energy subsidies cannot be allowed to persist if policymakers seek to reduce their prominence and promote a greener grid. Therefore, an

effective renewables promotion strategy necessitates the combination of several policies that tackle the multiple market barriers which confront renewable energies.

Effective policies exist and successful implementations are accessible to policymakers. Yet, tried and proven policies such as FITs have been passed over in many contexts, most notably in the US. Feed-in tariffs have only been adopted by 5 US states compared to 29 for RPS. According to the US Energy Information Administration, “FITs are comparatively new” and lack the deep historical policy antecedents that RPS policies dispose of. Additionally, when a form of feed-in tariff was passed with the Public Utility Regulatory Policies Act of 1978, the subsidy was based on ‘avoided costs’, an opaque and controversial measure which was heavily criticized by the industry and electricity payers as too high (Rickerson et al). Hence, given the preponderance of RPS and negative connotations associated with FIT-like policies, their adoption in the US has stalled. However, the policies are not mutually exclusive as FITs may be used in order to meet a state’s RPS target and there is some evidence that FIT deployment is increasing (Rickerson et al). Further research should be conducted to assert what steps policymakers should take to increase the acceptability of FITs and how to best deploy them.

References

IPCC, 2013: Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1–30, doi:10.1017/CBO9781107415324.004.

Benjamin, David N. *Embodied Energy and Design: Making Architecture Between Metrics and Narratives*. New York, NY: Columbia University GSAPP, 2017.

Menanteau, Philippe, Dominique Finon, and Marie-Laure Lamy. "Prices versus quantities: choosing policies for promoting the development of renewable energy." *Energy policy* 31, no. 8 (2003): 799-812.

Bator, Francis M. "The anatomy of market failure." *The quarterly journal of economics* 72, no. 3 (1958): 351-379.

"Arthur Cecil Pigou." Library of Economics and Liberty. Accessed August 18, 2018. <https://www.econlib.org/library/Enc/bios/Pigou.html>.

Beck, Fred, and Eric Martinot. "Renewable energy policies and barriers." *Encyclopedia of energy* 5, no. 7 (2004): 365-383.

Reiche, Danyel, and Mischa Bechberger. "Policy differences in the promotion of renewable energies in the EU member states." *Energy policy* 32, no. 7 (2004): 843-849.

Delmas, Magali A., and Maria J. Montes-Sancho. "US state policies for renewable energy: Context and effectiveness." *Energy Policy* 39, no. 5 (2011): 2273-2288.

Lewis, Joanna I., and Ryan H. Wiser. "Fostering a renewable energy technology industry: An international comparison of wind industry policy support mechanisms." *Energy policy* 35, no. 3 (2007): 1844-1857.

Sovacool, Benjamin K. "The importance of comprehensiveness in renewable electricity and energy-efficiency policy." *Energy Policy* 37, no. 4 (2009): 1529-1541.

Sawin, Janet, and C. Flavin. "National policy instruments: Policy lessons for the advancement & diffusion of renewable energy technologies around the world." *Renewable Energy. A Global Review of Technologies, Policies and Markets* (2006).

Haas, Reinhard, Gustav Resch, Christian Panzer, Sebastian Busch, Mario Ragwitz, and Anne Held. "Efficiency and effectiveness of promotion systems for electricity generation from renewable energy sources—Lessons from EU countries." *Energy* 36, no. 4 (2011): 2186-2193.

EU. European Commission. *The Support of Electricity from Renewable Energy Sources*. Brussels, 2008.

Haas, Reinhard, Christian Panzer, Gustav Resch, Mario Ragwitz, Gemma Reece, and Anne Held. "A historical review of promotion strategies for electricity from renewable

energy sources in EU countries." *Renewable and sustainable energy reviews* 15, no. 2 (2011): 1003-1034.

Yi, Hongtao, and Richard C. Feiock. "Renewable energy politics: Policy typologies, policy tools, and state deployment of renewables." *Policy Studies Journal* 42, no. 3 (2014): 391-415.

Shrimali, Gireesh, and Joshua Kniefel. "Are government policies effective in promoting deployment of renewable electricity resources?." *Energy Policy* 39, no. 9 (2011): 4726-4741.

Baranzini, Andrea, Jose Goldemberg, and Stefan Speck. "A future for carbon taxes." *Ecological economics* 32, no. 3 (2000): 395-412.

USA. EPA. *Sources of Greenhouse Gas Emissions*.

Bodansky, Daniel. "The Paris climate change agreement: a new hope?." *American Journal of International Law* 110.2 (2016): 288-319.

Solow, Robert M. "On theories of unemployment." In *Essential Readings in Economics*, pp. 264-279. Palgrave, London, 1995.

Rickerson, Wilson, Florian Bennhold, and James Bradbury. "Feed-in tariffs and renewable energy in the USA: A policy update." *Raleigh, NC, Washington, DC, and Hamburg, Germany: North Carolina Solar Center, Heinrich Böll Foundation North America, and the World Future Council*(2008).