Role of Fiscal Instruments in Promoting Low-carbon Technology Innovation

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Abstract

Many of the most promising low-carbon technologies currently have higher costs than the fossil-fuel based technologies. It is only through incremental learning from research, development and deployment that these costs can be reduced. Government intervention in the innovation process through fiscal policy instruments can be useful to accelerate this process, and catalyse early adoption. This paper reviews the best practices associated with the choice and design of such instruments and identifies the main lessons learned of their implementation in the case of renewable energy. The paper outlines an analytical framework which identifies the characteristics of drivers and barriers in innovation of RETs; sequencing of various steps involved in promoting innovation; and various policy tools in the context of each barrier that will help accelerate the process and enhance the outcomes. The paper notes that the issue of design and implementation of fiscal policy measures for RE technologies is complex and requires a nuanced, case by case approach, however, some useful broad conclusions can be drawn on the lessons learnt from these programs for future policy design and implementation.

Keywords: Fiscal instruments, Low-carbon technology continuum, Renewable energy policy framework, price and quantity based instruments, market failures and barriers in RE.

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Introduction

1.1 Need for Promoting Low-carbon Energy Technologies

Achieving the steep climate change mitigation targets the world is faced with would require both deployment of known 'low-carbon' energy technologies and invention of new technologies[1]. The magnitude and pace of technological transformation required in this context is highly challenging and unprecedented[2]. At least two key challenges differentiate this with other cycles of technological transformations, in general as well as specifically in the energy sector, than those encountered in the past—the need for systematically internalizing the externalities (social and environmental costs) and the huge upfront investment cost of technologies and supporting infrastructure (e.g. power lines to connect renewable plants, pipelines for CCS). These challenges are compounded by the absence of markets that could signal the real scarcities and the global scale of impacts that deems it necessary to have a faster pace of much needed innovation (Altenburg *et al,* 2014; Goulder and Parry, 2008; Narayanamurti *et al.,* 2011).

The emissions control policies (e.g. market-based − getting prices right ─ approach such as emissions pricing, emissions trading, environmental fiscal reforms) have been argued to be an efficient (cost minimizing) solution[3] to achieving GHG emissions reduction. For, these could potentially work as an incentive to technological innovation in low-carbon energy and also to changes in consumer behaviour. However, theoretical and empirical literature suggests that government intervention towards the innovation process through additional policies to promote low-carbon energy technology is necessary because environmental externalities are not the only market failure inherent in low-carbon energy technologies (*Box 1*).

[1]The IEA's Energy Technology Perspectives 2010 highlights the urgent need to deploy a wide range of low-carbon technologies in order to achieve the goal of halving greenhouse-gas emissions by 2050 while also promoting energy security (IEA, 2011).
[2]About two thirds of man-made greenhouse gas emissions result from burning of fossil fuels (IPCC AR5). Hence, we need a "fundamental transformation of the energy sector", including a "long-term phase-out of unabated fossil fuel conversion technologies" (IPCC AR5, WGIII.
[3]The economic efficiency argument favouring this approach is that it does not necessarily distinguish between the potential solutions—e.g. renewable energy, energy efficiency, CCS etc.

Box: 1

The energy sector is also affected by market failures associated with technology innovation and diffusion. The difficulty that industry faces in fully appropriating the benefits of research, development, and deployment (RD&D) and preventing competitors from capturing some of the benefits has been thoroughly explored in the economics and business literature, and represents one of the main justifications for government support of R&D (Jaffe *et al.* 2005).

Also, since emissions control policies provide innovation incentives only indirectly (by emissions pricing or by raising the costs of conventional production methods through direct regulation) these may be insufficient to foster the necessary investment in RD&D in new low-carbon energy technologies (Cohen and Noll, 1991); as well as to stimulate the dynamic learning process in known technologies to bring down the costs to an economically competitive level (Griliches 1992; Mansfield 1985; Levin *et al.* 1988; and Jones and Williams 1998).

Many of the most promising low-carbon technologies currently have higher costs than the fossil-fuel based technologies. It is only through incremental learning from RD&D that these costs can be reduced (IEA, 2010). Government intervention in the innovation process can be useful to accelerate this process beyond what would be expected from market forces alone, and catalyse early adoption.

For a discussion on the other barriers that impact the competitiveness of low-carbon energy and thus their penetration in the market, *see Section 2.3*.

Consequently, countries across the world (both developed and developing) have implemented a wide range of complementary policy instruments, including the fiscal instruments, to promote RD&D of low-carbon energy technologies (Azuella and Luiz, 2011). This, however, has been achieved with varying levels of success and with both direct and indirect costs (Gillingham and Sweeney, 2012). A snap shot of these instruments by stages of innovation is presented in *Figure 2* (*see Section 2.4.2.1*).

Public policy instruments by nature put pressure on governments' budgets and thus, in turn, have implications for their ability to sustain funding support to investment flows in low-carbon energy sector (UNEP, 2011).This is a serious concern and calls for efficiency in designing and implementing these instruments.

1.2 Objectives of the Paper

Against this background, this paper reviews the best practices associated with the choice and design of such instruments and identifies the main lessons learned of their implementation in the case of renewable energy (e.g. how to identify and design a policy to ease specific barriers for a given technology and other background variables; and how to identify a slowing down and an exit strategy). The remainder of the paper is organized as follows: *Section 2* outlines an analytical framework which identifies (i) the characteristics of drivers and barriers in innovation of RETs; (ii) sequencing of various steps involved in promoting innovation; and (iii) various RE enabling direct and indirect instruments and policies that will help accelerate the process and enhance the outcomes. *Section 3* reviews the different policy instruments deployed as support to RE technologies and provides useful insights on the lessons learnt from these programs for future policy design and implementation. *Section 4* provides some country case studies and best practices and experience with specific instruments, and *Section 5* concludes.

2. Choice and Design of CFPI

A number of domestic and international considerations both inform as well as influence the choice and design of CFPI in a country. The entire process from identifying the appropriate instrument to design and implementation of CFPI is a step-by-step process; and at each step a great deal of ground work including engagement with stakeholders is required. (*Figure 1*)

2.1 Setting the Stage: Drivers of Promoting Low Carbon Energy Technologies

Six drivers/energy development goals that, either alone or in combination, commonly shape energy development pathways, are identified (IRENA, 2013) as follows:

- Greenhouse gas (GHG) emissions reduction;
- Energy security;
- Energy access;
- Energy cost;
- International competitiveness; and
- Modernization

Broadly, these would guide the direction of the low-carbon energy technology policy as well as the choice of public policy instruments in promoting RD&D of low-carbon energy technologies. The choice of one or more of these goals and their relative weights will depend specific characteristics (e.g. demand/supply of energy, technical capacity, market structure, and existing institutions and regulations) of different countries. An analytical framework which identifies: (i) general characteristics of each driver/goal, (ii) various steps/functions involved in promoting innovation in the context of each driver/goal, and (iii) examples of policy tools that will help accelerate the process and enhance the outcomes is presented in *Table 1.* While the processes and end results appear to be significantly different across various national contexts, the framework is expected to be relevant to policy-makers in varied settings.

Figure 1: Choice and Design of Policies

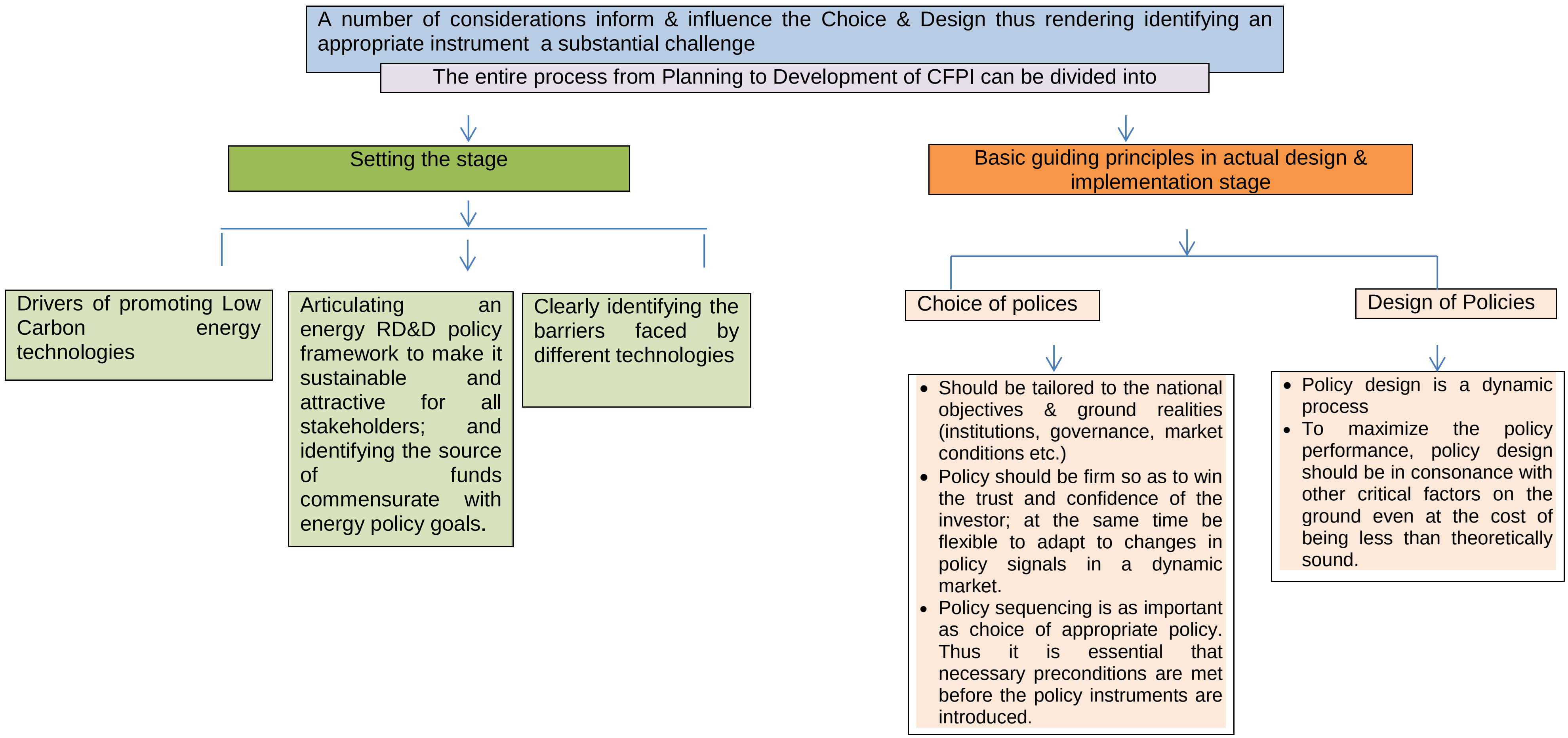


Table 1: Characteristics of Drivers, Functional Steps and Examples of Policy Tools

Drivers	Functions						
	Creating and Sharing New Knowledge	***Building Competence and Human Capital***	***Knowledge Diffusion / Creating Collaborative Networks***	***Developing Infrastructure***	***Providing Finance***	***Establishing Governance and the Regulatory Environment***	***Creating Markets***
	Policy Tools						
Energy Security (reducing dependence on vulnerable energy supplies)	Support studies to quantify value of energy security; High-resolution RET resource assessments; Grid Modeling to estimate performance under varying penetration levels of RETs.	Subsidies and incentives for education and training in power sector engineering, Project development, finance, engineering and construction.	Joining international cooperation seeking energy security; To identify gaps and prospects regarding energy use and efficiency.	Facilitating huge RET deployment via investment in grid infrastructure, roads, rail, and ports.	Project finance loan guarantees; "Green" banks or revolving funds; Public bonding support for infrastructure	Intellectual property protection and legal recourse for joint ventures; To improve investment climate; Specific and credible energy efficiency and renewable energy targets; Utility-scale interconnection standards.	Feed-in tariffs; Renewable Portfolio Standards; Government/public procurement.
	Policy Tools						
Energy access (reducing energy poverty and expanding access to secure, reliable, and low-cost energy)	High-resolution RET resource assessments in low energy access areas; Studies to quantify market size of low- and middle-income consumers; Opportunity and gap analysis of RET deployment in off-grid settings; Analysis of future grid modernization pathways.	Subsidies and incentives for education and training in off-grid system design and equipment maintenance, micro-grid design and engineering, power system planning; entrepreneurship, marketing, micro-finance.	Joining international cooperation for expanding energy access; Supporting community groups and entrepreneurs for RET deployment; Supporting micro-finance networks.	Enabling grid development in high-priority areas; Improving telecommunications coverage for novel smart grid applications.	Support energy technology micro-finance models; Removing barriers to Traditional and novel finance pathways.	Setting specific energy access targets; Establishing micro-grid interconnection standards, Bolstering property rights for low-income citizens; Removing barriers to new business models, e.g. solar system leasing.	Feed-in tariffs extending to micro-grid operators and low-income citizens; Public Procurement of RET systems in government-subsidized housing.
	Policy Tools						

Drivers	Functions						
	Creating and Sharing New Knowledge	***Building Competence and Human Capital***	***Knowledge Diffusion / Creating Collaborative Networks***	***Developing Infrastructure***	***Providing Finance***	***Establishing Governance and the Regulatory Environment***	***Creating Markets***
Cost (reducing exposure to persistently costly energy services)	High-resolution RET resource assessments; Energy road-mapping and System analyses; Grid capacity studies.	Subsidies and incentives for education and training in off-grid system design and RET equipment maintenance, micro-grid design and engineering, power system planning; Biofuels production, energy efficiency, entrepreneurship, marketing, micro-finance.	Initiating international cooperation; Supporting community groups for energy access and towards micro-finance networks.	Grid modernization; Vehicle electrification infrastructure; Biomass logistics and processing infrastructure.	Project finance loan guarantees; Alliance with international bodies to support financing and insurance of RET systems; Support for energy technology micro-finance models; Removing barriers to novel finance pathways.	Establishing distributed generation and micro-grid interconnection standards; Designating RET project development areas; Setting energy efficiency standards; Removing barriers to novel business models, such as energy performance contracting or solar system leasing.	Renewable Portfolio Standards; Feed-in tariffs; Energy Efficiency Obligations; Public procurement of RET systems in government buildings; Incentives for alternative fuel vehicles and energy efficiency.
	Policy Tools						
Competiveness (Trade; achieving greater competitiveness in international energy markets)	Detailed international market and supply chain studies; Detailed analysis of domestic industrial and service capabilities.	Subsidies and incentives for education and training in international business, foreign languages.	Brokering international joint ventures; International conferences to showcase indigenous capabilities; Supporting trade missions to markets; Participation in multilateral trade bodies.	Less critical in this policy setting.	Credit guarantees to improve creditworthiness of domestic firms in joint ventures.	Intellectual property protection and legal infrastructure to support joint ventures or international collaboration.	Less critical in this policy setting.
	Policy Tools						
Modernization (modernizing national	High-resolution RET resource assessments;	Subsidies and incentives for education and	Hosting conferences to showcase	Transmission expansion tailored to RE resources;	“Green” banks or other credit facilities; Project	Grid interconnection standards; Establishment of	Feed-in tariffs; Renewable Portfolio Standards;

Drivers	Functions						
	Creating and Sharing New Knowledge	***Building Competence and Human Capital***	***Knowledge Diffusion / Creating Collaborative Networks***	***Developing Infrastructure***	***Providing Finance***	***Establishing Governance and the Regulatory Environment***	***Creating Markets***
energy systems)	Energy road-mapping and associated System analyses; Grid capacity and expansion studies.	training in power sector engineering, renewable resource assessment, project development and system engineering, finance, and international business.	investment opportunities; Brokering International joint ventures; Supporting reverse trade missions to firms.	Enhancements to shipping and Logistics infrastructure.	finance loan guarantees; Credit guarantees or other instruments to improve creditworthiness of domestic firms in joint ventures.	priority transmission zones; Enhancements to intellectual property protections and determinants of investment climate.	Government/public procurement.
	Policy Tools						
GHG emissions reduction, focusing on reducing the GHG and impacts on environment	Subsidies for basic research stimulate international technology and knowledge flows.	Subsidies and incentives for education and training in power sector engineering, project development, finance, engineering, and construction.	Joining international cooperation seeking GHG emission reduction; to identify gaps and prospects regarding energy use and efficiency.	Facilitating RET deployment via investment in grid infrastructure, roads, rail, and ports.	Project finance loan guarantees; ”Green” banks or revolving funds; Public bonding support for infrastructure	Intellectual property protection and legal recourse for joint ventures; To improve investment climate; Specific and credible energy efficiency and renewable energy targets; Utility-scale interconnection standards.	Feed-in tariffs; Renewable Portfolio Standards; Government/public procurement, carbon pricing, reforming subsidies to fossil fuel based energy.

Source: Authors’ construction based on IRENA, 2013

2.2 Setting the Stage: Need for an Energy RD&D Policy Framework

A particularly challenging issue is how to identify which technologies need to be promoted, which underscores the need for a comprehensive energy RD&D policy framework. Appropriate energy RD&D policy frameworks[4] are one of the cornerstones of energy technology promotion. A coherent and co-ordinated RD&D energy strategy – with clear prioritization in line with national energy policy goals – is the most important feature of a good practice energy RD&D framework (Fulton, 2011) (*Box 2*). Such a strategy, when based on a dynamic strategic vision (developed in close consultation with major stakeholders and frequently updated) can improve the confidence and trust of potential investors in the reliability of targets and policy ambitions, and thus boost the pace of RD&D of low-carbon energy technologies (IEA, 2011; Pandey *et al*, 2014; Kammen*, et al*, 2004).

Box: 2

An energy RD&D policy framework based on good practices

1. Coherent energy RD&D strategy and priorities
2. Adequate government RD&D funding and policy support
3. Co-ordinated energy RD&D governance
4. Strong collaborative approach, engaging industry through public private partnerships (PPPs)
5. Effective RD&D monitoring and evaluation
6. Strategic international collaboration

Source: IEA, 2011

Germany's integrated climate and energy policy, and RE Technologies planning

- Germany has set a target of 30 per cent RE by 2020 and 50 per cent by 2030.
- The National RE Action Plan (NREAP) projected that it would achieve 38.6 per cent RE by 20202 (projection of how the market might grow).
- To meet national targets and NREAP trajectories, Germany projects that the two fastest growing RE technologies will be wind and PV during 2010-2020.
- Wind will, therefore, contribute 48 per cent of total RE in 2020 and PV will account for 19 per cent.
- Projections are made for both total installed capacity as well as annual additions. These details enable the government to design strategies for volume management.

Source: Based on Fulton, 2011

A review of energy RD&D priorities in select countries based on announced technology programmes/ strategies is presented in Annexure A. *Such an exercise can be a used as a guide by countries to help draw clear linkages of policy instruments with the targets as well as assist in monitoring the impact of policy instruments.*

[4]Which is seen as a constantly evolving process – defined by an approach to: creating change through continuous learning and adaptation; and supporting development and promotion of a variety of technologies as well as different organizational types of energy production (e.g. centralized vs. decentralized electricity generation).

In addition, a strong commitment from governments to make RD&D a sustainable and attractive proposition for all stakeholders is important. This is achieved when clearly defined energy production goals and realistic targets -- and not *ad hoc* programmatic or fiscal interventions--guide the medium-term to long-term direction of the energy innovation portfolio (Pandey *et al*, 2014; Kammen *et.al* 2004; IEA, 2011; Fulton, 2011). For example, countries with small grid capacities may need to set targets which would reflect constrained grid capacities and, hence, may initially promote distributed generation over centralized generation. Similarly, in the case of both wind and photovoltaic (PV) technology, the promotion of power storage technologies would dramatically enhance their effectiveness.

According to Margolis and Kammen (1999); and Kammen *et al* (2004), many R&D programs with *ad hoc* funding cycles can at times do more harm than good to RD&D of specific technologies. For example, R&D programs in USA, for solar and fuel cell systems were not focused on committed goals but instead on spending available funds, which often had to be justified on unrealistically short timetables.

Further, characterization of technologies by the stages of technology development can help contextualize the types of innovation activities that are possible and/or necessary to advance a given technology at a given time, and thus help determine which types of policy instruments, and the level and duration of support might be appropriate for a technology at a specific stage of risk and maturity[5.]

2.3 Setting the Stage: Barriers in Development & Adoption of low-carbon Energy Technologies

A clear understanding of the barriers faced by different low carbon technologies is required to develop the relevant and effective policies. To set the context, we briefly discuss the common barriers in investment in low-carbon energy, although the significance of one barrier over the other may vary across the countries, technologies, organizational types of energy production (e.g. centralized *vs.* decentralized electricity generation) and stages of RD&D etc. (*Box 3*)

Besides, some key characteristics of technologies and projects that may be relevant in identifying market barriers are:

- *Relative maturity*: The commercial maturity of technology reduces the risk to the investor and is capable of overcoming market barriers. However, the regional specificity of the technological issues will still be valid in certain cases; for example, integrated gasification combine cycle would require demonstration and validation in developing countries owing to the issues emanating from varying qualities and composition of the coal feedstock.
- *Base-load versus variable*: The intermittent output from many RE systems is a critical performance weakness and remains a hindrance to their substitution for base-load thermal generation. The technologies pertaining to demand side management and energy storage may address the challenges associated with such systems.

[5]Feedbacks and linkages are often present between these different stages, and the boundaries between them are porous: for example, feedback from the market and from technology users during the commercialization and diffusion phases can lead to additional RD&D, driving continuous innovation (IEA, 2011).

- *Policy dependence*: Investment in many energy technologies is highly dependent on regulatory decision to allow, mandate, or facilitate their use with adequate financial support. The financial attractiveness of wind turbines, solar, power and other forms of distributed power generation requires favourable polices for access to utility grids and, very often, direct government subsidization.

Box 3

- Inadequate pricing of environmental externalities (lack of/ imperfect emissions policy);
- Market failures in protecting the benefits of innovation/knowledge , and external benefits of learning-by-doing[6];
- Policy barriers (such as fossil fuel subsidies) which artificially reduce the competitiveness of low-carbon technologies (in most countries, subsidies to support the production and consumption of fossil fuel-based energy are more than the subsidies to low-carbon energy); and
- Market failures due to imperfect information and distortions (high transaction cost of information, principal agent problems, policy co-ordination problems (Groba and Breitschopf, 2013).

Besides, fossil fuel based technologies have several other advantages, which work as barriers for low-carbon energy, such as:

- Well-organized energy markets and delivery systems for conventional energy;
- Availability of supporting infrastructure;
- Consumers' familiarity with costs, risks and performance;
- Financial sector understands the risks and market demand etc. relatively better.
- Institutional barriers (gaps in institutional capacity to support adoption of new technologies and to monitor and enforce performance standards).

Although market failure and barrier is used here interchangeably a distinction is often made in the literature (Groba and Breitschopf, 2013). While the standard characterization of market failures is the inability of the markets to fully internalize the social costs/benefits in pricing mechanisms, the market barriers are disincentives adversely impacting market entry and/or adoption/use of solutions/devices/products and services. Further, while market failures, as the term suggests, are necessarily linked to the poor functioning/absence of markets, market barriers could be linked to the functioning of the markets, regulatory and fiscal policies, social and cultural factors, and asymmetric information etc.

- The most documented market failure in the case of most technologies is the difficulty in protecting research, especially basic research. This may also be interpreted as the inability in fully capturing/appropriating the benefits of R&D (Goulder and Parry 2008). Empirical studies suggest that the (marginal) social return to innovation in general

[6]Although market failures are not limited to the clean energy sector, the case for public policy support for clean energy technologies in the context of climate change mitigation is magnified due to the need for quick and decisive actions owing to the threat of climate change, and lingering uncertainties about how climate change policies will play out in terms of their impacts on relative price of low-carbon energy and thus enthusiasm for innovation in low-carbon energy (Fischer and Newell 2007; Montgomery and Smith 2007).

might be greater than the (marginal) private return (Griliches 1992; Mansfield 1985; Levin *et al*. 1988; and Jones and Williams 1998). In addition, research may unintentionally produce results that the innovator cannot use effectively. Not being able to reap full gains from investment may mean disincentive to the innovator/investor resulting in less than optimal investment in low-carbon technology R&D, thus justifying governmental intervention in the form of public sector research, subsidies for private R&D, tax credits, stricter patent rules, etc. While *appropriability* (AP) issue may arise in all three phases of the innovation, R&D spillovers may be much more important for very early stage R&D, rather than for technologies at the pilot or implementation stage (Nordhaus, 2010).

- Another market failure may arise from *knowledge spillovers* post pilot stage of innovation. It is usually argued that *learning-by-doing* (LBD)[7] is necessary in bringing down the costs of technologies. This is supported by empirical evidence (Ek and Söderholm, 2010; IEA, 2010; Isoard and Soria, 2001; Junginger *et al.,* 2010; Kahouli-Brahmi, 2009; Klaassen *et al.,* 2005; Neij, 2008; Söderholm and Klaassen, 2007) though actual size of learning rates may vary widely for specific technologies (Lindman and Söderholm, 2012). However, competitors may benefit by the external benefits of the efforts of early adopters. Consequently, investments in learning will be sub-optimal in stimulating the efficient levels of cost reduction thus adversely affecting the pace of adoption. Empirical evidence on LBD is still limited (Lehman, 2013) relying primarily on anecdotal observations (Junginger *et al,* 2005). An econometric analysis is provided by Braun *et al.* (2010) which using patent data, shows that innovation in wind and solar technologies is strongly driven by knowledge spillovers. Gillingham and Bollinger (2012) is another analysis that distinguishes appropriable LBD (internal learning) and non-appropriable LBD (external learning) in the cost of an installation of PV in US, and finds clear evidence for both types of learning at the country level and for the state of California. Empirical evidence on the extent of the LBD spillovers as well as AP is limited constraining the optimal policy design.
- Innovation in low-carbon energy technologies often has very high capital requirements, and involve long time horizon. Like any R&D it involves substantial economic, technical and regulatory risks that hamper access to finance. Economies of scale[8] can be considered a barrier or market failure if there are capital constraints or a simultaneous coordination problem. Capital constraints issue is likely to be more significant in emerging economies which lack active investors, venture capitalists, and private equity institutions. However, quantifying LBD separately from the economies of scale and exogenous technologies change is a difficult empirical challenge for which there is only very limited evidence (e.g. Nemet 2006; Gillingham and Bollinger 2012).
- Simultaneous co-ordination problems are more likely to occur in developing a new infrastructure for electric or hydrogen vehicles (Gillingham and Sweeny 2010), provision of smart grid etc.
- Yet another potential market failure may arise from consumer myopia causing undervaluation of benefits of energy efficiency/low-carbon energy. In addition poor

[7]LBD implies that the unit cost of a product/service decreases with increasing cumulative investment, production, and market growth.

[8] Other barriers related to the technical and economic characteristics of RE stand in its way of diffusion besides its capital intensive profile include the need to mobilize mass production effects rather than scale effects because of their size limitations, and in certain cases their failure to generate energy on a continuous basis (Menanteau *et al* , 2003).

information and cultural and social barriers to do things differently present strong resistance to adoption.

While identification of specific barriers that limit the progress in RE technology innovation and diffusion in general is required, it is necessary to differentiate the barriers by different RE technologies and different stages of innovation (Gillingham and Sweeney 2012). The tables below make an attempt in addressing this (*see Tables 2* and *3*).

Table 2: Market Failures and Barriers in Renewable Energy by Technologies

Technology	Market failure	Remarks	Barrier	Remarks
Central generation	AP and LBD are relevant.	The evidence on the extent of the AP and LBD remains limited. Also, quantifying LBD separately from the economics of scale and exogenous technologies change is a difficult empirical challenge.	Capital constraints and simultaneous coordination problem.	A simultaneous co-ordination problem has some similarities to a public goods problem, and may provide motivation for either government co-ordination of different agents or possibly government provision of the good or service.
Distributed RE	AP and LBD may be relevant.		These technologies may face the same barriers as in central generation.	The only major difference is that, in this case, consumers (and sometimes firms) are the purchasers of the technology, rather than electric utilities as in the case of centralized generation.
CCS Technologies	Theoretically same AP issues are likely to apply in the case of CCS.	However, currently since much of the research in this area is in the public sector the AP would not apply.	The most fundamental barriers to CCS are high cost (early stage technology which is highly energy intensive).	Concerns of leak out of carbon, risk of abrupt release of CO_2 and the consequent liability risk and public acceptance.

Source: Based on Gillingham and Sweeney, 2012.

2.4 Guiding Principles Underlying the Choice and Design of Instruments

Broadly there are three important issues in choice and design of instruments: (i) identifying the appropriate instruments which would successfully address the identified barrier/s; (ii) assessing how well the instrument will perform on the identified performance criteria (e.g. target for RE, per unit cost reduction); and (iii) at what cost. These are discussed in what follows. The discussions draw from the theoretical literature as well as from select literature on recent country experiences and thus serve as a lesson for designing and implementing CFPI. It is important to note that the discussions and resulting suggestions should be seen in light of the fact that there may be multiple barriers and performance criteria, and a large number of other policy and general business environment related factors in individual countries informing as well as influencing both the design and the performance of a policy. However, there is limited understanding on how policies designed to address different priority issues play out though interactions.

Table 3: Market Failures and Barriers in Renewable Energy by different Stages in Innovation

Phases of Innovation	Market Failures	Barriers	Potential Policy Instruments
Birth Phase (R&D) Basic research to fundamental breakthrough Conceptual breakthrough to lab scale model	Positive externality Inability to appropriate full benefits of R&D and knowledge spillovers	Under investment in R&D relative to economically efficient level.	Subsidize R&D; Government investment in R&D; Soft loans; Tax credit
Survival Phase (Deployment) • Lab – to – pilot • Targeted deployment • Untargeted diffusion	Positive externality • This is learning by doing phase for cost reductions. Learning spill-over is a strong possibility • Economies of scale	Under production relative to economically efficient level. The pace of deployment may be adversely affected. • Capital constraints and/or co-ordination problem	Subsidize production and implementation of technologies
Growth Phase (diffusion) This represents market penetration through acceptance of the innovation by potential users of the technology. But supply and demand side factors jointly influence the rate of diffusion.		Slow adoption • Institutional barriers • Access to finance	To create a technology push • R&D support • Financial incentives • Procurement initiatives • A carbon tax on fossil fuels • Production tax credit • Low interest loan
Commercialization of a new product, material or process with potential for immediate utilization. Depends on technical, economic factors etc.		• Capital constraints • Simultaneous coordination problem	• Production tax credit • Renewable portfolio standards (RPS) • Investment subsidy to solar panel & wind turbines in USA • FIT • Public Utility Regulatory Authority in USA to purchase RE at a price not higher than their avoided costs to promote RE • In Germany RE prices (for producers) were tailored to each type of RE since each technology faces different cost of generation • Netherlands enacted Demand pull eco-tax: producers of RE receive production subsidy & households are exempt from eco-tax on RE
Adoption	Behavioural issues • Consumer myopia • Cultural issues • Information gaps • Split incentive issues	• Capital constraints • Simultaneous coordination problem	• Capital subsidies • Soft loan • Labelling • Regulatory standards • Tax incentives

Source: Authors' construction

2.4.1 Choice of policies

Although a number of considerations, with significant overlap among them, would determine the choice of policies, there are some general points which may be used as broad guidelines.

- The choice of appropriate policy instruments will also depend on how optimal the policies dealing with GHG emissions are? For instance, in the presence of a sub-optimal emissions policy − such as when emissions pricing is just a token (e.g. a tax on carbon emissions with no link to emissions reduction targets in a country) and/or covers only a few sectors of the economy − the role of CFPI can be seen as a way of correcting negative environmental externalities resulting from the use of fossil fuels and of addressing market failures in the low-carbon energy technology market, whereas in the presence of an optimal emissions policy along with a clear roadmap to fossil fuel subsidy reform, the role of CFPI can be seen as a way of achieving dynamic efficiency by stimulating technical change. (Fischer, et. al 2012).
- Even with strong emissions policy, certain technologies that require large capital investment to scale up in order to realize cost reduction are likely to face barriers, if there are capital constraints or a simultaneous coordination problem. Therefore, a policy mix incorporating targeted regulatory, fiscal, and financial policies will need to be designed (IRENA, 2013).
- Certain technologies may require special consideration. For example, breakthrough technologies such as CCS which may have the potential to produce dramatic results (Fischer and Newell, 2007) may require, among others, direct support by way of grants and facilitation of international collaboration.
- Availability of empirical evidence (e.g. considerable uncertainty remains regarding LBD for a wide range of technologies (Doner, 2007) on how knowledge spillovers contribute to hampering the development/penetration/adoption of different clean energy technologies. Status of many critical factors such as skilled manpower, R&D capability, strong supporting institutions and capacity for developing systems for price discovery (e.g. auctions, reverse bidding) significantly influence both the choice of CFPI and their impact.
- Maturity of clean energy market, regulatory provisions such as long term policy and financial commitment to buy/mainstream RE, and targets for clean energy is some other important determinants of CFPIs. Whether or not Policies at the sub-national levels are in agreement and consistent with national policies and goals may also impact the performance of a policy/instrument.

2.4.2 Design of policies

The most important aspects of designing CFPIs are the determination of the support level and the duration of the support. This is more complex than it may seem. For instance, policy instruments that would effectively promote basic R&D are different from those needed to stimulate dynamic learning process and bring down the cost of technology. This emphasizes the need for differentiating technologies by stages of technology development and identifying specific barriers faced (*Figure 2*). Further, as the RE technologies evolve, markets mature and the costs of RE lowers, the financial support to RE will need to be gradually phased out. This would require that the design of the support scheme has the built flexibility in level and time frame to accommodate changes in the development of costs and technologies without any adverse impact on the momentum of potential innovation, pace of RE generation targets and other drivers. In this context, first a brief discussion on policy mechanisms available to policy makers is in order.

2.4.2.1 Public Policy Mechanisms Available to Policy Makers. Broadly, fiscal policies commonly refer to tax and public expenditure based measures such as accelerated depreciation; tax holidays for initial years of the project (post-commissioning); tax rebates through waiver/reduction of import duties and excise duty (tax on production of goods); and capital subsidy (grants, soft loans). They are, invariably, based on the size of the investment/actual installation of the equipment; are not linked to the use or performance of the equipment; and there may be some (e.g. tax incentives and subsidies for projects in designated areas/special economic zones etc.) that are not even linked to the actual activity and/or use of specific technology or quantity of power generation.

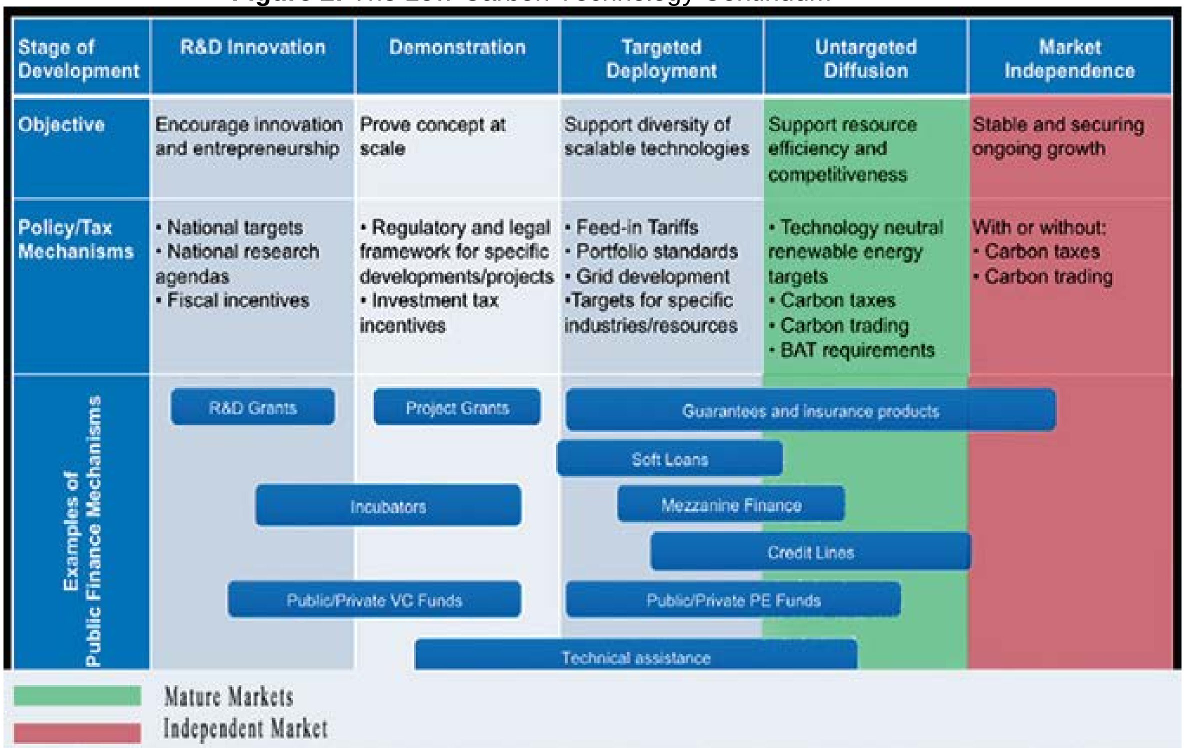
Financial incentives, on the other hand, are (mostly) directly linked to the actual amount of generation and, in some cases, on the amount of investment, e.g. policies such as FITs, generation-based incentives (GBI). Financial instruments are often designed to address financial barriers, such as access to capital, high perceived risk to the sector, etc.

UNEP (2011) defines public finance mechanisms (PFMs) as financial commitments made by the public sector that alter the risk-reward balance of private sector investments by reducing or removing barriers to investment. It further states that while policy instruments that set the overall economic framework conditions for investment in low-carbon technology such as FITs, carbon taxes and renewable portfolio standards (RPS) are not regarded as PFMs, their presence has a significant effect on the success of a given PFM. They should, therefore, be taken into account when evaluating the context in which successful PFMs operate.

In this paper CFPIs are taken to be a combination of supporting regulatory policy and tax mechanisms, and PFMs to support investment in low-carbon energy technologies. This is because of the interdependencies (e.g. presence of RPS can enhance the effectiveness of FIT) between them and the fact that different types of instruments are required along the low-carbon technology continuum. A suggestive framework for Public Policy mechanisms through five different stages of the technology continuum is provided in *Figure 2*. This framework not only differentiates a whole basket of policy instruments between regulatory, fiscal and financial instruments but also by different stages of innovation and at the same time provides a suggestive link between the primary objectives through various stages of innovation.

Although carbon pricing/trading would provide some R&D incentives but it cannot simultaneously address the multiple market imperfections involved in achieving cost-effective GHG emission reductions. Therefore, the overall mitigation costs may be lowered by combining policy instruments according to their comparative advantage in addressing each market imperfection (*Box 4*). Polices focusing on reducing the cost of R&D in low-carbon technologies such as a tax credits, investment tax breaks (accelerated depreciation etc.), subsidy for capital costs (grant, soft loan), institutional support (government funded research facilities, support for getting patents) and stricter patent rules thus have an important role to play in incentivizing investment in R&D and thus lowering the cost of low-carbon energy technologies.

Figure 2: The Low-Carbon Technology Continuum



Source: Ibaris and Climate Bonds Initiative (2011); UNEP (2011)

Besides the policies that deal with general innovation and diffusion failures/barriers, the policy makers would need policies to address those innovation and diffusion failures that are specific to low-carbon energy technologies through technology adoption instruments (e.g. supporting RE generation (ensuring viable markets) through a subsidy (feed-in-tariff (FIT)) or production tax credit, in USA, or RPS (creating market share) requirement).

Box 4

For instance, based on a theoretical model calibrated on US electricity sector data, Fischer and Newell (2007) suggest that optimal R&D and renewable subsidies could lower (by over a third) the CO_2 emissions price needed to achieve a 5 per cent cut in emissions from US electricity sector and could bring down the overall cost of the policy package to zero, due to the positive spillovers generated by the technology-support policies.

Fischer and Newell (2007) find in the absence of any price to GHG emissions, technology support policies do not provide a cost-effective way to stimulate innovation and technology diffusion. The study finds R&D subsidies to be the costliest policy option to reduce emissions from electricity production, followed by RE adoption incentives, emissions performance standards and emissions pricing.

However studies by Jaffe and Stavins (1995); and Hassett and Metcalf (1995) find larger effects from technology cost subsidies than from energy taxes on EE improvements in USA.

2.4.2.2 CFPI differentiated into market-pull and technology-push policies. This differentiation is helpful in identifying the right instrument and its appropriate design. *Table 4* presents a broad categorization of these. While the demand-pull policies aim to increase the RE demand by addressing environmental externalities or reducing market barriers, technology-push policies primarily aim at increasing the incentives to generate new knowledge and further work on the available knowledge to improve upon its performance and cost.

The technology-push policies can be classified into fiscal measures (e.g. grants, rebates, tax credits), financial measures (e.g. direct investment, soft loans, credit risk guarantees etc.), institutional support (government funded research facilities, support for getting patents) and stricter patent rules to reduce the upfront costs and risks of investments (Mitchel et al 2011). These directly target and incentivize the private investment in various stages of technology development and diffusion. Technology-push policies are especially important in pushing investment in early stages of innovation due to various risks and uncertainties around the chances of success and the time taken in reaching the commercial stage.

Market pull policies include both quantity based (e.g. carbon trading mechanism, RPS); and the price based (e.g. carbon tax, FIT) instruments which can be either technology neutral (e.g. carbon tax, carbon trading mechanism) or target specific technologies (e.g. FIT, RPS).

Table 4: Strategies and Selected Policies for Promotion of Renewable Energy

<table>
<tr><td colspan="5">Market-pull policies</td></tr>
<tr><td rowspan="2"></td><td colspan="3">Technology-specific (direct)</td><td rowspan="2">Non-technology-specific (indirect)</td></tr>
<tr><td></td><td>Price-driven</td><td>Quantity-driven</td></tr>
<tr><td rowspan="2">Market-based</td><td>Investment incentives</td><td>• Investment subsidies
• Tax credits
• Supportive tax policy
• Tenders (prices)</td><td>• Tendering systems for investment grants (quantity)
• Quotas (capacity)</td><td rowspan="2">• Environmental taxes
• Emission trading</td></tr>
<tr><td>Generation incentives</td><td>• Feed-in tariffs
• Premium feed-in tariffs</td><td>• Energy portfolio standard (quotas) in combination with tradable green certificates
• Tendering systems for long-term contracts</td></tr>
<tr><td>Command-and-control</td><td></td><td>• Technology and performance standards
• Authorization procedures</td><td></td><td></td></tr>
<tr><td rowspan="2">Voluntary</td><td>Investment Promotion</td><td>• Shareholder programs
• Contribution programs</td><td></td><td rowspan="2">• Voluntary agreements</td></tr>
<tr><td>Generation promotion</td><td>• Green tariffs</td><td></td></tr>
<tr><td colspan="5">Technology-push policies</td></tr>
<tr><td></td><td colspan="4">• Public R&D spending (direct funding, grants, prices)
• Tax credits to invest in R&D
• Capacity enhancement for knowledge exchange
• Support for education and training
• Financing demonstration or pilot projects
• Market engagement/incentive programs/public procurement
• Strategic development policies
• Technology exhibitions/fairs
• Network creating/building</td></tr>
</table>

Source: Groba and Breitschopf (2013)

As a general rule, policies such as R&D support, financial incentives, and procurement incentives are more suitable for stimulating commercialization and initial market creation for new technologies, which can create a technology push. Once a technology is established in the market, further growth can be stimulated by policies such as FIT, RPS and other financial incentives.

An important issue, however, is to strike a balance between technology- push and market-pull measures from the beginning. To do so, policymakers need to understand how these measures interact under and respond to different market conditions[9]. This however is an area for future research; although some discussion on this is available in Dong (2012) that points toward more empirical research on the structural reasons for a country to adopt a given policy. This should be done in a technology, country and a case specific way.

2.4.2.3 Design of CFPIs: Some Guidelines and Knowledge Gaps.

(i) The comparative Efficiency of Different policies

The following criteria are suggested in analysing the impact of different CFPI (Menanteau et al 2003):

- Capacity to stimulate RE generation
- Incentives to reduce costs and prices
- Incentives to innovate
- Overall cost to community

Table 5 presents relative merits of some policy instruments on these criteria. As a general point, it may be noted that in the case of pollution control methods, price based (P) and quantity based (Q) schemes produce similar results when all the necessary information is available. However, the outcome of these two approaches will tend to differ when information is incomplete (Cropper and Oats, 1992). One or the other of these will be preferred depending upon the relative slopes of the marginal abatement cost curve and the damage curve (Weitzman, 1974). In applying these concepts to stimulate low-carbon energy generation, a simplified argument would be that a Q based approach[10] would be preferable when the slope of the MC is relatively flat. Conversely, a P instrument such as FIT[11] may lead to significant increase in supply and consequently in

[9] For a discussion on interaction among policy instruments for GHG emissions-reduction (e.g. carbon pricing, carbon trading etc.) *see* Sorrell, 2002; Sorrell and Sijm, 2003.
[10]In a Q based approach regulator defines a reserved market for a given amount of RE and organizes a competition between producers to allocate this amount. Competitive bidding system limit the margin with respect to risk and thus may result in much more limited installed capacities. But, under a bidding system, the level of subsidies for renewable electricity generation can be controlled unlike the case of feed in tariff.
[11]A FIT is a policy mechanism where eligible renewable electricity generators are paid a cost-based price for the renewable electricity they supply to the grid which ensures that investors get guaranteed income that covers costs and also get additional return on capital sufficient to motivate investment. A differentiated tariff approach attempts to give each producer what it required to maintain production so that the optimal market quantity of renewable energy production can be reached.

Table 5: Criteria for Choice and Design of Instruments

Instrument	Design	Incentives to reduce costs and prices	Capacity to stimulate RE generation	Stimulation of technical change	Cost to community	Remarks
Feed – in – Tariff (Price based systems)	Government sets a price and markets determine the quantity of RE at that price. Effectively it involves a subsidy to the producers of RE. Whereas a regulation (RPS) makes it obligatory for the electric utilities to mix RE in its portfolio.	No incentive to producers; government has no direct control on Q; Governments have introduced a provision to gradually reduce FIT to take account of progress in RE technologies. FIT does not encourage innovation because of guaranteed prices.	• Reduces risk for RE developers. Thus encourages capacity generation. • Low risk and transactions cost and potential to reduce costs provides strong incentive to add more capacities. • Has better L-R effects are promoting wind energy.	• Increase in installed capacities lead to cost reduction and consequently improved margins. This enables producers to invest in R&D. • Strong incentive to invest in R&D to consolidate their industrial base. • Strong incentive to producers and manufacturers who would benefit from reduced costs and thus higher surpluses.	• Costly in terms of subsidies but simple to administer • Q can exceed the targets. • Support for RE is unrelated to electricity price charges.	• Useful in supporting certain technologies that may have potential but not fully developed thus expensive. • Useful if the objective is to develop local manufacturing and other capacity for installation and servicing. Potential benefits employment and export earnings.
Reverse auctions FIT	This system was a competitive process to award its FIT entitlements assessed on multiple performance criterion including the price. In this scheme government sets a Q and markets determine the FIT price subject to a performance assessment.	No incentive to producers to reveal cost reduction	• Revenue certainty leads to investment in capacity. • Bidder pre-qualifications assessment is important to ensure capacity generation is delivered.	• Incentive to reduce EPC capital cost.	• Subsidy can be controlled. • Significant transaction costs.	• Cost effective in the case of established technologies.
Competitive bidding	Government sets a quantity and organizes competitive bidding from RE producers to allocate this amount at prices determined by them. Electric utilities and obliged to purchase RE from selected RE producers.	• Strong incentive to producers to cut production costs	Limited margins with respect to risk will result in limited capacities.	• Relatively their margins limited R&D below optimal. • Surplus generated from reduced costs is shared among producers, manufacturers, and consumers/tax payers • Incentive to reduce EPC capital cost	• Through indirect controls level of subsidies can be controlled. • Significant transaction costs. • Support for RE is unrelated to electricity price charges.	• Prudent in the case of established technologies.
Green certificates (Quantity based	Green certificates are attributed to RE generators who sell	Strong incentive to control both equipment and operating costs.	More adapted to liberalized energy markets.	Strong incentive	• Potentially the most efficient way for distributing the overall RE target	

Instrument	Design	Incentives to reduce costs and prices	Capacity to stimulate RE generation	Stimulation of technical change	Cost to community	Remarks
approach)	power at wholesale market prices; and sell certificates to operators who have a particular quota to meet under this system RE generation objective are imposed on retailers/distributors for allocation efficiency when they have access to different resources.				among several technologies and organizing RE development on a large scale. • Costs are distributed equitably among consumers. • This system makes it possible to use least cost source for a single technology (such as wind before PV). But may prevent investment in promising but has developed technology.	
RPS	Renewable Portfolio standard is structured as a quantity regulation, letting the market determine the price for RE. Governments set targets to ensure a certain mix of RE in total generation capacity. In most cases REC are created to track the performance. RECs allow for trading in the market as penalties are imposed for non-compliance.	Strong incentive, as RPS can potentially incentivize competition among different RE technologies.	Could provide incentive to producers in S-R Provides incentive to utilities to either produce RE or buy REC. A properly designed RPS and well-functioning REC markets are required. This implies a long-term policy and targets on RE and strong regulator	Likely to create a competitive environment for all RE technologies and thus provide incentive to R&D.	Flexibility of RPS allows generators to comply at least cost.	For wind E cost curve is relatively flat so Q instrument would be superior to price investment. In the case of wind E, RPS is a market based system and thus favoured over FIT according to Environmental Economics theory arguments; as FIT is subject to price control.
Investment Subsidy	Directly reimburses the capital investment on equipment or total capital cost of the project.	No incentive to producers	Strong incentive (Key to growth in WE in Denmark)	May be	yes	• Useful in supporting certain technologies that may have potential but not fully developed thus expensive.

subsidies. It can then be argued that the Q based approach is the more effective in controlling the cost of government incentive policies whereas in P based systems (e.g. FIT), production cannot be anticipated with any precision because of the uncertainty regarding cost curves. Therefore, if the emphasis is on fast pacing the RE generation and also keep a check on the cost of subsidies the policy maker should choose a combination of the Q (e.g. RPS) and P instrument such as competitive bidding (CB) system[12] which provides incentive to reduce costs *vis-a-vis* FIT, since competing producers must reflect lower costs in prices in order to win subsidies. However, this may or may not work for all types of technologies. Dong (2012) finds that FIT has better long term effects in promoting wind energy, although in the short-run RPS could also provide some incentives to developers.

However, a cautious approach would be required. For, it may be argued that the bidding approach may lower the price and the cost of RE, though this price reduction may not be due to technical change but may happen due to systematic effort to reduce costs through economies of scale and use of the very best sites available. In terms of efficiency, in the price vs quantity debate whichever system is chosen, the main objective in the medium to long-term in most cases will be to stimulate technical progress such that the gap between the costs of low-carbon energy and existing technologies continuously narrows down.

Dong (2012) shows that the technological learning effects have been much greater for manufacturers in countries that have opted for FIT. An explanation would be that the surplus that goes to the producers in Q based approach is limited whereas technical change tends to increase the producers' surplus in the case of P based approach (e.g. FIT), thus encouraging them to innovate more.

According to Menanteau et al (2003), if social preference is attached to climate change prevention and reflected in a high quantitative objective for RE, FIT is a good compromise in order to promote technical progress. The quota/certificate system also presents a number of advantages in terms of static efficiency, but its ability to stimulate innovation has still to be confirmed by experience. They also derive that in terms of installed capacity, from an empirical point of view, P approaches yield better outcomes than the Q approaches. This is ascribable to the strong incentive effect of fixed prices that induce greater stability and predictability in the incentive systems for the investors. However, in terms of control over costs, the system of fixed feed-in tariffs renders it difficult to anticipate the level of RE production on account of uncertainties of cost curves. Thus, in this respect, quantity-based approaches induce lower costs as bidding for successive quotas provides an indirect way of controlling overall costs.

Madlener *et al* (2010) considering a perfectly competitive market with the possibility of technological innovation, and contrasts guaranteed FIT for RE with traded green certificate from the point of view of social welfare as well as dynamic efficiency. The main finding is that subsidy policies are preferable in terms of dynamic efficiency. However, the P approach dominates the Q approach in terms of social welfare if the assumption of perfect competition is relaxed.

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[12]CB schemes allow indirect control on public expenses through successive quotas. However, transaction costs for both producers and government are lower in FIT vis-à-vis CB.

The criterion of the dynamic efficiency of the incentive instruments enables the approach to be extended beyond examining simply the effects of reduced costs over a short period. Dynamic efficiency (establishing sustainable technical progress) has two components: one part that relates to the technological learning process pertaining to wider diffusion of technologies, and the second that depends on the manufacturers' R&D investments and thus on surpluses that might be generated. Thus if the objective is to encourage local R&D to achieve the goal of developing a competitive RE industry, some protection to the domestic industry will be required before it can be opened to the external competition. A FIT system will be helpful in such a situation (This is evidenced by the fact that Germany, Denmark, and Spain are the world leaders in wind turbine production).

Green certificates will be more compatible with the liberalization of the electricity market. The system of tradable green certificate is similar to a Q based mechanism but differs from a bidding system in that each operator is assigned a quantitative objective. The potential advantage of green certificate trading system is that the goal of new energy generating capacity can be achieved in a cost effective way by distributing the overall objective among several technologies. But given the limited experience with green certificates, and the number of challenges (e.g. those associated with the risk of small number of participants, risk of price volatility, other transaction costs, creation of floor prices, ability to enforce penalties due to complex market structure and political infeasibility on defaulters) its real efficiency has still to be proven (Fristrup, 2000). A framework to redistribute funds collected through penalties will contribute in improving the acceptance of investors.

(ii) *Important empirical questions around inherent flexibility and time-frame of support*

As the RE technologies evolve, markets mature and the costs of RE lowers, the financial support to renewables will have to be gradually phased out, with the exception of the support for R&D expenditure to immature new technologies on the anvil with good long-term potential. Thus, the overall framework conditions which constitute the best-practices with regard to cost components and its calculation, automatic tariff degression and time frame for support are discussed below (European Commission, 2013).

For competitive allocation schemes, *cost calculations* can serve as a reference for the policy makers or as benchmark for technology-staggered auction processes. Typically, cost calculations comprise three distinctive steps: (i) selection of cost parameters (capital and operating costs, fuel costs, network and grid connection costs, costs of market integration and such like) and a cost calculation methodology, (ii) setting the cost and revenue projections, and (iii) translating the levelized cost of electricity into an actual support level.

Incentive/ support schemes have to remain flexible enough to adjust as technologies evolve on the global market, mainly due to learning curves and technological innovation that lead to costs reductions. Consequently, it is suggested that schemes should include *automatic tariff degressive characteristics*, as also built-in revision mechanisms.

For most RE technologies characterized by medium to long time period for maturity, the *time frames for support* broadly vary between ten years to over twenty years, with most offering support for between eleven and fifteen years. Generally, shorter support periods entail a lower risk of regulatory change. In comparison, the longer the time frame, the greater will be the need for flexible, market-adapting schemes, to avoid frequent regulatory adjustments. An alternative to formulating time bounds in terms of years is to limit support in terms of "number of full-load hours supported". This approach comprises converting the number of years to be used as the time limit into a fixed amount of cumulative production to be supported, by relying on a reasonable assumption about the average/ typical capacity utilization factor.

(iii) Issues in how to allow built-in flexibility level and timing of slowing and an exit policy

The main questions are: at what cost, for how long, and how it should be distributed? These are particularly tricky questions and would require a case by case examination, analysis and solutions. Although interesting insights from some of the evolving literature on evaluating the impact of CFPIs and using feedback loops in phasing out of CFPI can be very useful.

A key consideration in this context from an efficiency and cost effectiveness perspective would be to give an operational perspective to the choice and design of instruments by evolving a framework for optimal plan for offering and then phasing out these incentives/measures. This, among other things, would include: an understanding of market dynamics, interactions among policy instruments, an understanding of entry points both in scale and magnitude, a slowing/course correction strategy (by incorporating feedback loops, learning by doing, information diffusion) and an exit strategy as market dynamics change.

The important of making policies predictable, stable in medium to long-term to reduce the risk and uncertainty that investors and consumers face has been emphasized in the literature. For instance, Production Tax Credit for wind turbines in USA which had to be periodically renewed caused large fluctuations in wind capacity as opposed to consistent yearly growth of the wind industry in Denmark which provided direct subsidy which remained unchanged for many years (Doner, 2007).

Further, some technologies may need policy intervention in the early stages of market transformation to remove market barriers, which will increase the sale of new technologies and through learning and scale economies will accelerate the reduction in per unit costs. This results in a positive feedback loop that can lead to rapid market growth (Doner, 2007). The key message in this research is that you should take into account these feedback loops, such as LBD, and information diffusion when designing a policy/phasing-in the incentives. These are important in determining how to distribute the subsidies to both accelerate the diffusion and optimize the total subsidy. This was supported by an empirical study for Germany (Lobel and Perakis, 2011) which shows that stronger subsidies in the beginning, and a faster phase-out would have been more cost efficient in Germany.

Lobel and Perakis (2011) modeling the adoption of solar photovoltaic technology as a diffusion process (where customers are assumed to be rational agents following a discrete choice model) show how this framework can be used by policy makers to design optimal incentives to achieve a desired adoption target with minimum cost for the system. In particular, this policy design model takes into consideration network externalities such as information spread and cost improvements through LBD. The paper shows that the current solar policies in Germany are not efficient. More subsidies should have been required in the beginning — a stronger subsidy policy, perhaps — and a stronger phase-out in the later stages of the program. The reasoning is that in the early stages of the adoption process, it is optimal for the government to provide strong subsidies, which take advantage of network externalities to reach the target adoption level at a lower cost. As the adoption level increases, these network externalities become saturated and the price paid for raising the adoption target becomes increasingly more expensive[13].

3. Design and Implementation of CPFI: Best Practices and Lessons learnt

We now identify and discuss the best practices associated with the design of the instruments as well as the main lessons learned of the implementation of RE policy tools. In what follows immediately, the regulatory and policy environment for RE development and deployment is presented.

3.1 Policy Context in which RE Technology (RET) Development and Deployment Incentives have Emerged

It is important to understand the policy environment in which measures towards promoting RET development and deployment have emerged in developed and developing countries. This helps identify the context in which specific factors have proved conducive to or barriers to effective dissemination of RETs. On the one hand, a strong political will and compliance with international treaty/ agreement has favoured the development of RETs, while on the other hand, planning and bureaucratic hurdles and grid connection issues have hindered their effective deployment. Policy design and implementation can also be linked to the market structures in the economy. The tabulation below is elucidatory (*Table 6*).

Table 6: Policy Context within which RE Technology Development and Deployment Incentives are Placed

Policy Impacts	Policy Context	Country-wise Analysis
Policy supports	Presence of a clear political resolve	*China:* Presence of a definitive political resolve has led to the successful design and implementation of policies and support measures for encouraging RETs in China. China, is now a world leader in non-hydropower RE capacity (at 70 GW at the national level by 2011), and has installed more wind turbines and manufactured more solar PV panels than any other country in the world. The impressive growth of RE capacity (from 27.8 Gigawatt (GW) in 2001 to 183 GW in 2013, with share of RE to account for 20 per cent of aggregate electricity generation in the country by 2020) can be ascribed to a clear political will, combined with an aggressive pricing mechanism and a strong manufacturing base to back this process. Chinese RE law of 2006 had specified time-bound goals and objectives for RE development and deployment. These were aided by complementary measures toward diversification of the energy mix, development of a strong indigenous manufacturing base, and putting in place aggressive incentives mechanism. Support instruments instituted by the National Development and Reform Commission (NDRC) of China included reliance on competitive bidding system. Subsequently, in 2009, a move to feed-in-tariffs differentiated by type of wind energy resources we

[13]The qualifier is that due to limited access to data this is not a full empirical study of the German solar market. We have very limited access to data.

Policy Impacts	Policy Context	Country-wise Analysis
		instituted. Companies that won the bid were provided guaranteed grid access through a power purchase agreement, coupled with a range of complementary measures such as preferential loan and tax conditions, and financial support for road and grid extension (WWF and WRI, 2013). *Germany:* Germany too exhibits a strong and steadily rising share of RE in electricity, heat and biofuel sectors. In 2012, RE generation, including hydropower, accounted for 23.5 per cent (140,000 GWh) of total power consumption in the country, up from 11 per cent in 2005 and a mere 4.3 per cent (19.000 GWh) of total power consumption in 1990. In 2000, the Erneuerbare-Energien-Gesetz (Renewable Energy Sources Act –EEG) was made effective, which has been the primary instrument for promoting RE in the electricity sector of Germany. The EEG received immense support from parties across the entire political spectrum of the country. RE development was also incorporated as an integral part of the industrial development policy, complemented by Germany's commitment to shift from nuclear and fossil fuels to RE. The other key policies driving RE dissemination have been the market incentive program for renewable heat generation and the tax exemptions in the bio-fuel sector. The success of the EEG can be attributed to a stable flow of investment, priority grid access and sufficiently high feed-in-tariffs for renewables (Jager and Rathmann, 2008). *Japan:* In Japan as well, it was the National Energy Law (1997) that specified the target for RE in aggregate primary energy supply. This was supported by RE promotion rules on how the costs of grid reinforcement were to be financed, and how the transmission networks were to be improved and maintained (Jager and Rathmann, 2008). RES-E has generally relied on support from a Renewables Portfolio Standard (RPS) scheme that was launched in 2003. RPSs have been implemented for a range of technologies, namely, offshore wind, onshore wind, solar PV, solar thermal electric, CSP, biomass, small hydropower and geothermal. Besides RPS, voluntary agreements between government and energy suppliers to buy electricity generated from RE at the residential retail price (suitable feed-in-tariffs) that were introduced in 1992 have also been a significant determinant of power generation from RE until 2002. Solar PV plays an important role in the Japanese power system. The financial support for PV has been mainly aimed at RD&D schemes. In the past, the thrust on the development of PV cell technology was achieved mainly through the Moonlight and Sunshine Projects in the 1970s and 1980s.
	Countries' compliance with international environmental treaties	*Canada:* So far, the development and deployment of RES in Canada is largely confined to hydropower and some biomass. Since the late 1990s, a number of support policies and measures were instituted by the federal and provincial governments, but these were not adequate to stimulate significant RE development. It is after the adoption of the Kyoto Protocol in December 1997 that a fresh thrust on policy and measures supporting RE investment and deployment were introduced in Canada. Prior to this, efforts were concentrated on competitive technologies such as large hydropower and biomass for application in paper and forest product industries. Recently, the key support instruments that have been put in place at the federal government are a feed-in premium for almost all RES-E technologies and flexible depreciation on investment cost. Conditional on the specific project, complementary instruments have been used, such as investment subsidies and low interest loans (Jager and Rathmann, 2008).
	Mix of domestic policy resolve and compliance with international environmental	*India:* Presently, the RE development and deployment in India is guided by the targets laid down in the various national Five Year Plans (FYPs), the National Action Plan on Climate Change (NAPCC) and the Jawaharlal Nehru National Solar Mission (JNNSM). Thus, the driving factors in India have been a mix of national policy resolve and requirements placed by the international treaties. The 11th FYP(2007-2012) set a target of additional

Policy Impacts	Policy Context	Country-wise Analysis
	treaties	12.4 GW of grid connected RE that was exceeded with actual installation being over 14 GW during this period (ABPS Infra, 2009). The target set for the 12thFYP (2012-17) is 30 GW of RES-E with the following mix of technology: 15 GW wind, 10GW solar and 2.1 GW of small hydro (Government of India, 2013).The NAPCC was launched in 2008 and envisages around 15 per cent electricity consumption from RES by 2020. Under the umbrella of NAPCC, the JNNSM was initiated that sets out a target of 22 GW of solar capacity by 2022 in both grid- and off-grid modes. It also proposes an integrated approach to policy support, including support toward R&D, manufacturing development and market deployment (EPIA 2012, MNRE (GoI) and WWF and WRI, 2013). So far, in India, reliance has been placed on both quantity and price based measures, namely RPO scheme with tradable renewable energy certificate scheme and feed-in-tariffs. Despite the impressive growth, India continues to face the challenge of broad basing RE development and deployment as, so far, this has been restricted to select states.
Policy barriers	Complex administrative and planning procedures and grid connectivity constraints	*France:* Due to these barriers, there has been only modest development of RE in France in the recent past. Currently, the dominating RES-E technology in France is hydropower, although, there exists large potential for wind and biomass based energy. The French feed-in-laws are beset with complicated administrative and planning procedures that diminish the realized potential of the incentives put in place. RES support in France has been mainly provided through three instruments: feed-in tariff for RES-E, multiple tax reductions for RES in all the sectors, and different subsidy programs run by the French Environment and Energy Management Agency (ADEME). The specific structure of the scheme has varied across regions and tends to be subject to frequent changes. Despite relatively high feed-in tariffs, RES-E and, especially wind energy development, has been hindered by bureaucratic planning regulations. The change of regulatory procedures in 2005 has somewhat improved the situation, in that, in 2006, with newly installed capacity of 810 MW, France managed to more than double its market for wind power (Jager and Rathmann, 2008). Italy: Similar constraints can be observed in case of Italy, where the production of RES-E from wind and biogas sources has displayed some increase, but this has not been commensurate with the growth of aggregate electricity consumption. The incentive and support measures instituted by the Italian authorities have been generally unstable. Moreover, the administrative procedures for grid connection have been long and complicated, entailing high transactions costs. During the 1990s, the most important incentive for penetration of RES-E was feed-in-tariff. Since 2001, there was a move toward a quota obligation with tradable green certificates. In 2005, a separate feed-in tariff for solar photovoltaic was put into practice. A switch back to feed-in-tariffs for most technologies is imminent, which will replace the quota obligations. In spite of these measures, the development and deployment of RES-E has been disappointing – mainly due to political, administrative and financial reasons. Further, no specific national support instruments have been implemented for RES-H (Jager and Rathmann, 2008).
Policy performance linkages	Size of the economy and the market structures therein.	*Select emerging economies:* Azuela and Barroso (2011) find a clear distinction between large and medium-size countries (defined in terms of gross national income and size of power sector) in the variety of instruments found in the policy package. In general, Brazil, India, and Turkey have implemented a more diverse set of mechanisms to promote RE than Indonesia, Nicaragua, and Sri Lanka. Also, BRICS countries Brazil and India have been relying on more evolved types of instruments (well-developed FIT design, REC market, and auctions). Furthermore, the policies to support RE have been more effectual in the higher-income countries (Brazil, India, and Turkey). This could also be due to other complementary factors, such as the domestic investment climate, economic and political stability, and governance and institutional issues. In

Policy Impacts	Policy Context	Country-wise Analysis
		comparison, low RE market growth has been exhibited in both Indonesia and Nicaragua for reasons related to policy or contract design in combination with select external or background factors (such as regional financial crises, governance constraints, or regulatory uncertainty).

Source: Authors' compilation

Against this backdrop, we discuss the country experiences with use of incentives and support measures for RE development and deployment and allude to the lessons learnt there from.

3.2 Effectiveness and Efficiency of Support Schemes for Development and Deployment of RETs: Lessons Learnt from Country Experiences

Designing policy for RE programs requires choice of instruments based on many criteria – policy effectiveness in terms of stimulation of RE deployment, cost effectiveness indicators for the economy, incentives to reduce costs and prices and incentives to innovate/ technological learning or market maturation (Menanteau et. al., 2003). A discussion is now presented on how the deployment policy instruments for RE technologies has performed on these accounts in terms of select country experiences (IEA, 2008 and IEA, 2011). The discussion forms the basis for dos and don'ts for future policy design and implementation.

Three key sets of support schemes have been taken up for analysis:

- *Price based market instruments such as feed-in-tariffs (FITs) and feed-in-premiums (FITPs):* FITs/ FITPs are price based regulatory instruments wherein producers are assured a set price or premium per unit by the government for the electricity produced, irrespective of the amount generated. An important difference between FIT and premium payment is that the latter induces competition between producers in the electricity market, while the former may not directly induce competition. The public utility is obligated to connect the RE generator to the grid and pay a pre-determined rate/ premium for the life of FIT/ FITP contract, usually 10-20 years, to lower market risks to investors. Both FITs and FITPs are structured to stimulate specific technologies and cost reductions (latter though a phased reduction in tariff/ premium).
- *Quantity based market instruments called renewable portfolio standards (RPSs) or quota obligations:* RPS is a form of quantity regulation in which a target or quota obligation is set by the government in order to ensure that a set market share of energy (say, in the form of electricity) comes from RE sources (Dong, 2012). Here, a retailer is obligated to include energy generated by renewable sources into his portfolio. Generally, RPS use tradable/ non-tradable renewable energy certificates (RECs) or tradable green certificates (TGCs) to create a market for environmental attributes (as in the UK) although this not always the case (as in California, US). A TGC is an official record certifying that a particular amount of RE has been generated. Quota obligations with TGCs are generally technology-neutral support mechanisms, aiming at promoting most cost efficient technology options. Since an RPS relies on the private market for its implementation, it allows for competition among different types of RE. It also permits RE sources to compete with the cheaper fossil fuels in the long run due to efficiency and innovation.

- *Tendering/ competitive bidding:* A tender is announced for providing a certain quantity of electricity from a specific technology source, and the bidding process ensures that the lowest offer is accepted. The structuring of competitive bidding can range from a single bid to multiple rounds of bidding. Under the single bid arrangement, power producers bid for providing a fixed amount of RE level, and the lowest price-bidder wins the bid. Under multiple rounds of bidding, there are multiple winners and with each successive round of bidding, the price quoted by the bidder gets reduced, thereby reducing the cost of RE provision (Beck et al, 2004). Tendering allows for incorporation of additional conditions, e.g. mandated local manufacturing of technology.

Next, the discussion focuses on the impact of support measures on stimulus to RES-E based on the policy impact indicator (PII) and the cost-efficiency of the support scheme by relying on the total cost indicator (TCI). Both the indicators have been harmonized by the International Energy Agency (IEA) to allow cross-country comparisons (IEA, 2011). In addition, the other impacts studied pertain to incentives toward technology cost reduction and technology market maturation based on Jager and Rathmann (2008), which indirectly point toward incentive to innovate.

3.2.1 Stimulus to RES-E

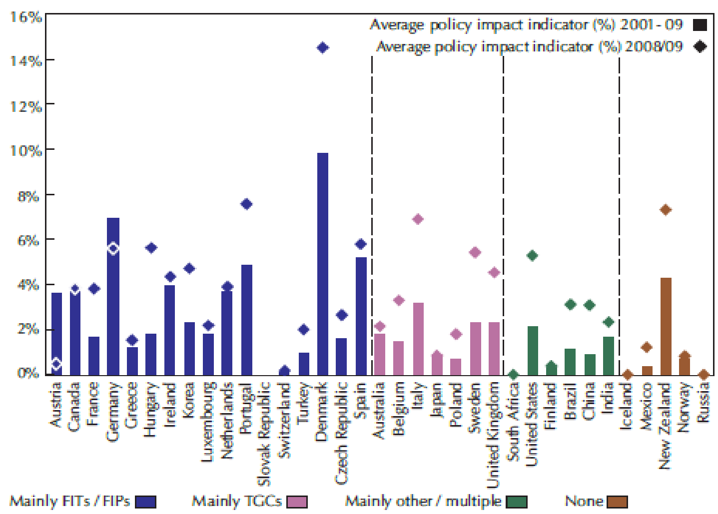
The level of market deployment of a technology can be measured by the stimulus provided to RES-E. IEA has been relying on the PII for the OECD and BRICS countries, with focus on wind power and solar PV. PII measures the progress toward a defined goal and provides a measure of the impact of policies on stimulating RE deployment. It calculates the percentage of gap between the 2005 generation and the World Energy Outlook (WEO) 2030 target that was achieved in a given year. The indicator helps in comparing policy effectiveness across countries in stimulating the deployment for different technologies. The sample included 35 countries, of which 17 were using FITs, 6 were relying on certificate schemes and 5 were without any policies.

3.2.1.1 Policy impact indicator (PII) for onshore wind. Observably, for the entire span of period 2001-2009, the average PII in countries with reliance on FITs was 3.23 per cent, 1.5 times of the level for countries using certificate schemes (at 2.1%). Of the ten countries with the highest PII, the top eight were using FITs (namely, Denmark, Germany, Spain, Portugal, Ireland, Canada and Netherlands), with New Zealand ranking fifth albeit absence of a dedicated policy support. The only country amongst the top ten that exhibited reliance on certificate schemes was Italy (*Figure 3*).

Interestingly, however, the difference in PII values has decreased between FITs and certificate schemes: the country average being 4 per cent for FITs and 3.6 per cent for certificate schemes in 2008-09. Of the top ten countries in 2008/09, six utilized an FIT (namely, Denmark, Portugal, Spain, Hungary, Germany and Korea) and two a certificate scheme (Italy and Sweden). New Zealand ranked third, and the US ranked ninth (with relying on federal tax credits and state-level quota obligations, some of them combined with a certificate system).

In general, the average impact of both FITs and certificate schemes has risen over time. But certificate schemes have displayed a stronger relative increase. Based on the 2009 data alone, TGCs systems fared even better than FITs (4.75% versus 4.36%). The reasons for this development could be traced to a number of factors. First, the RE systems may have encountered strong learning effects, more so in recent years. Another reason may be the low baseline effectiveness level of certificate systems to start out with, and deployment on select sites rendered easier after some level of learning is attained. This conclusion is corroborated by the observation that two countries using an FIT and with high past effectiveness are now demonstrating lower levels (namely, Germany and Austria).

Figure 3: PII for Wind Support Policies in OECD and BRICS Countries, 2001-09

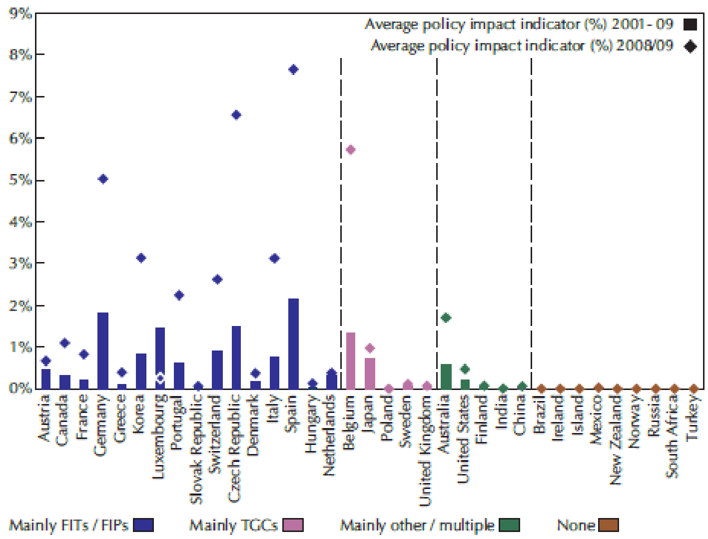


Source: IEA, 2011

3.2.1.2 Policy impact indicator for solar PV. The comparative analysis of PII is now presented for 35 countries of which 18 countries have been using FITs, 5 are relying on certificate schemes and the rest have various other support policies in place. The average PII for countries using FITs is much higher (at 0.83 for the overall time period 2001-09 and 2.13 in 2008-09) as compared to those relying on certificate schemes (which are found to be at 0.43 for 2001-09 and 0.42 for 2008-09). Moreover, countries that succeeded in deploying solar PV (with the exception of Belgium) used FITs to do so. This is due to the fact that certificate schemes' objective was to use the least-cost options, implying that more expensive options (such as solar PV) did not witness any marked deployment (*Figure 4*).

In general terms, the policy effectiveness of solar PV deployment has risen overtime, as PV markets have evolved and matured. Moreover, FITs and FITPs have been most effective in stimulating PV deployment. According to IEA, in terms of country-wise impacts, five distinct categories can be identified (*Figure 4*). The first group comprises countries that display little or no noticeable rise in PV deployment and have very low domestic policy support levels (namely, Brazil, China, South Africa, Mexico, Russia, Norway, Iceland, New Zealand, Turkey, Ireland, Hungary and Denmark). The second group exhibits very low levels of deployment, even though the policies provide for substantial financial support (as in India and, to a lesser extent, Greece with 2010 effectiveness of 3.3%). Evidently, non-economic barriers are inhibiting larger levels of deployment in these countries. The third group displays a steady and smooth increase in policy effectiveness over time (as in case of US, Japan, Switzerland and Canada) or an established effective policy environment (Germany). In contrast, the fourth group includes countries that have seen a sudden jump in policy effectiveness (namely, Australia, Belgium, Italy, Austria, Slovakia, France and the Czech Republic). The last group witnessed a peak in effectiveness but thereafter very low levels of deployment. This consists of Spain (where there was a boom in 2008, followed by a phase of market constraining in 2009 and 2010) and, to a lesser extent, Portugal and Korea (*Figure 4*).

Figure 4: PII for Solar PV Support Policies in OECD and BRICS, 2001-09



Source: IEA, 2011

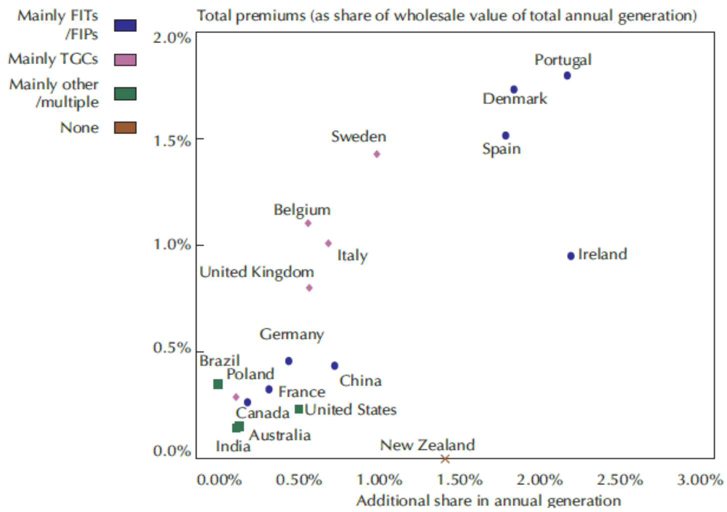
3.2.2 Cost effectiveness

As deployment volumes reach a large scale, a concern that has arisen relates to the overall cost of the policy to the economy in the form of support tariffs, premiums and subsidies. The varied types of power market structures render it problematic to assess the additional premiums that are paid in excess of the market price. Thus, IEA has attempted to quantify the total cost of policy support across the same group of countries, the total cost indicator (TCI). The TCI is defined as the amount of additional annual premiums paid for an additional unit of generation per year. For normalization across countries, the annual premiums are expressed as a percentage of the total wholesale value of all the electricity generated.

3.2.2.1 Cost effectiveness indicator for onshore wind. On a broader spectrum, countries show very large dispersion of total premium payments as measured by the TCI, and a generally positive correlation between TCI and deployment of wind power. The lowest values have been exhibited by New Zealand, where no incremental premiums were required to be paid for the 1.5 per cent of electricity that was covered by new wind generation in 2009. This is followed by India and Australia. Ireland too paid relatively smaller premiums and displays low TCI in comparison to the extent of stimulus to wind power. The premiums were comparably large in Sweden, taking into account the smaller contribution of new wind generation. Portugal paid the highest total premiums for wind power capacity that was deployed in 2009, which is why it also reaped a large amount of additional generation from wind power. Similar results can be observed for Spain and

Denmark (*Figure 5*). It can also be seen that FIT and FITP exhibit a better trade-off than TGCs between wind's additional deployment and total premium costs.

Figure 5: Total Cost Indicator for Onshore Wind, 2009

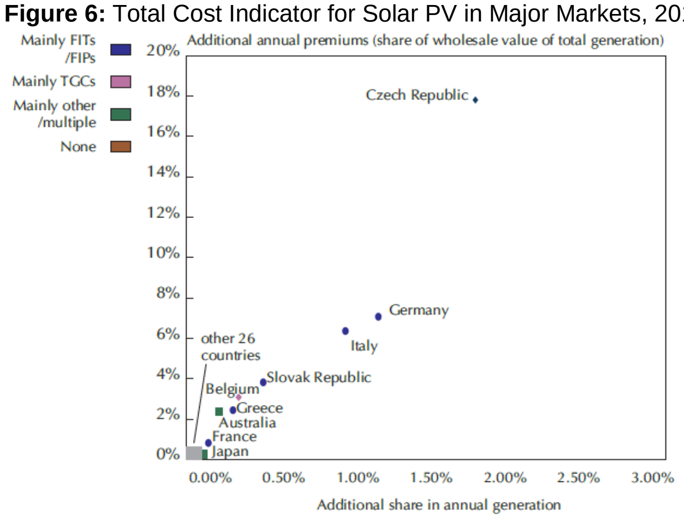


Source: IEA, 2011

3.2.2.2 Cost effectiveness indicator for solar PV. As the diffusion of some RE technologies such as solar PV are still in nascent stage of the learning curve, at large volumes of deployment, the total support cost indicators have come under policy review. In general, solar PV support deems it necessary to have payment of comparably high premiums. To evaluate the aggregate burden that support policies put on the national energy economy, the TCI was worked for the incremental generation produced in 2010 (*Figure 6*). Due to its relatively small size, combined with very high tariffs, the Czech Republic displays the largest burden with respect to its overall power system: the share being almost double of that for Germany. Also, compared to onshore wind, much larger premiums need to be paid.

3.2.2.3

Figure 6: Total Cost Indicator for Solar PV in Major Markets, 2010



Source: IEA, 2011

3.2.3 *Contribution of scheme toward cost reduction for technologies and level of market maturation*

In terms of static efficiency, the incentive to reduce costs is mainly experienced in the case of competitive bidding and TGCs (as the producers tend to be price takers). In comparison, the FITs/ FITPs do not provide the same level of incentive for cost reduction. However, once the dynamic effects are internalized in relation to the stimulus to RES capacities (these largely operating through the effects of learning curves on cumulative production) FIT is likely to perform relatively better in terms of the overall installation than competitive bidding or TGC systems. That the system that performs better dynamically is the one that stimulates RE market is corroborated by the data below (*Table 7*).

Table 7: Contribution of the Support Scheme to Cost Reduction of RES and lLvel of Market Maturity

Country	**Instrument characterization**	**Contribution of the scheme towards reducing the costs of RES**				**Market maturity level**
		Wind- onshore	Wind-offshore	Combined heat and power biomass combustion	Solar photovoltaic	
Canada and Canadian Provinces	Production incentive	Insignificant	Insignificant	Insignificant	Insignificant	Moderately mature
Ontario	Feed-in-tariff	Significant			Moderately significant	Moderately mature
	Tax incentives					
	Competitive bidding: Tender (contract price)					
Quebec	Competitive bidding: Tender (contract price)	Significant				Moderately mature
France	Feed-in-tariffs	Significant	Significant	Significant	Significant	Emerging
	Competitive bidding:/ tendering					
	Tax measures					
Germany	Feed-in tariff	Significant	Significant	Significant	Significant	Fully mature
Italy	RPS (Quota obligation)	Significant	Significant	Significant	Significant	Emerging
	Feed-in-tariff	Significant	Significant	Significant	Significant	Emerging
Japan	RPS (Quota obligation)	Insignificant		Insignificant	Insignificant	Moderately mature
Netherlands	Feed-in-premium	Significant	Significant	Moderately significant	Insignificant	Moderately mature
Norway	Investment subsidy	Moderately significant	Insignificant	Moderately significant		Emerging
Spain	Feed-in-tariff/ feed-in-premium	Significant	Insignificant	Moderately significant	Significant	Fully mature
	Tax deduction					
	Low interest loan					
UK	RPS (Quota obligation)	Significant	Moderately significant	Moderately significant	Insignificant	Moderately mature
	Tax deduction	Significant	Moderately significant	Moderately significant	Insignificant	Moderately mature
	Investment subsidy	Significant	Moderately significant	Moderately significant	Insignificant	Moderately mature
US & US	Production tax	Insignificant		Insignificant	Insignificant	Fully mature

States	credit					
California	RPS (Quota obligation)/ production incentive	Significant		Significant	Significant	Fully mature
Minnesota	RPS (Quota obligation)	Moderately significant		Moderately significant	Moderately significant	Moderately mature

Source: adapted from Jager and Rathmann, 2008

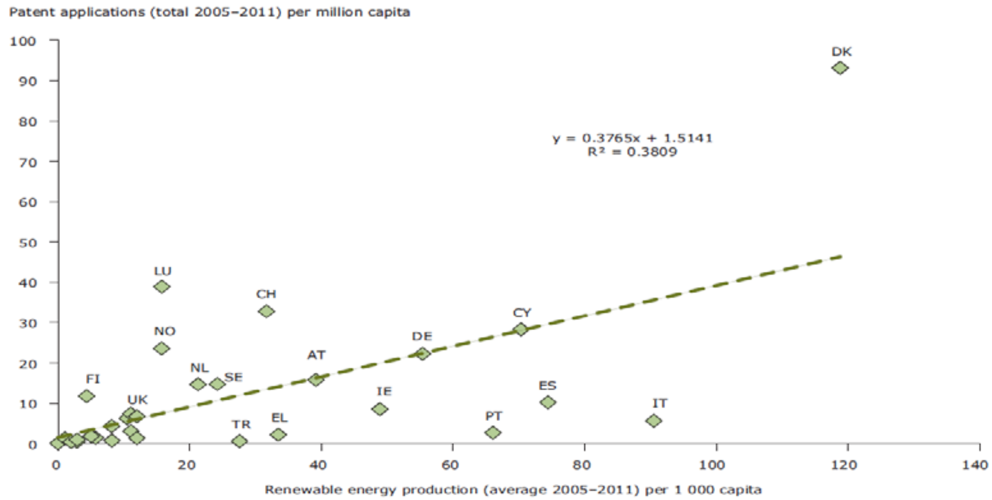
As can be seen from the 2006 data for select OECD countries where the RE support policies have been in place for some time (Jager and Rathmann, 2008), price instruments FITs and FITPs have generally performed better in reducing the cost of technology (significantly or moderately significantly) than quota obligation (with TGCs), competitive bidding, production and other fiscal incentives. Moreover, wind (both on-shore and off-shore) technologies exhibit the highest possibility of cost reduction, followed by combined biomass power and heat, with the lowest cost reduction experienced in case of solar PV. Notably, however, the cost reduction trends here have been reported only for the most dominant instrument used in a country and not available for all the others. Further, evidence is weak as to whether FITs or FITPs are associated with mature markets for technologies in comparison with quota obligations or tendering schemes.

3.2.4 Impact on innovation

There is lack of conclusive evidence on the link between energy support measures and innovation (EEA, 2014). It depends critically on the original goal of the energy support measure: attaining social equity and access, achieving energy security, correcting for externalities, supplementing domestic production and spurring employment. The data from EEA for the EU-27 group of countries for the period 2005-2011 demonstrates a weak relationship between per capita RE production (wind, solar and geothermal) and per capita patent applications granted in (*Figure* 7). Denmark is the only exception: it exhibits a much larger share of patents compared to the other countries. This is followed by Luxembourg, Norway and Switzerland, which too display a relatively high number of patents compared to their RE generation from these specific technologies. In comparison, Italy, Portugal, and Spain have much fewer patents applications as compared to RE generation. This leads to the conclusion that a mere strong focus on deployment (demand-pull) does not necessarily lead to accelerated innovation in the renewable sector. In contrast to the above findings, there is clear evidence that public support for R&D have proved to be an important driving factor for innovation. *Figure 8* demonstrates that there exists a strong positive correlation between R&D expenditure by the government and patents applications.

The case of four countries (of the EU-27), namely Czech Republic, Netherlands, Switzerland and Spain, are illustrative. For these four countries, *Figure 9* depicts the data on share of RET patent applications in the total patent applications in EU-27 and Switzerland between 2006 and 2010 (the years being different due to data limitations). As can be seen, for Spain RE deployment had led to substantial R&D activity. Spain demonstrated a very high share in patent applications for wind, and a relatively high share for solar PV as well. There was a rapid increase in the number of patents for both these technologies between 2006 and 2010. In comparison, however, for concentrated solar power (CSP), Spain had a relatively low share in patent applications during this period, despite CSP being acknowledged as an important technology. By contrast, Switzerland demonstrated the highest share in CSP and solar PV patent applications, despite very low deployment rates. The same holds true for Netherlands.

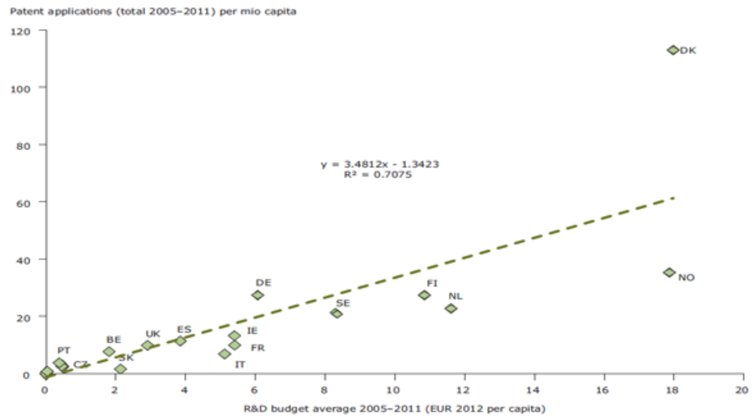
Figure 7: Patent Application *versus* Renewable Energy Production Per Capita in Select Countries



Note: These technologies were selected as relatively new renewables technologies, and production was calculated as an average over the period from 2005 to 2011. In addition, an analysis for the total renewable energy production would be heavily influenced by hydro electricity production, and would show less clear linkages with patent applications.
Country codes: AT (Austria), BE (Belgium), BG (Bulgaria), CH (Switzerland), CY (Cyprus), CZ (the Czech Republic), DE (Germany), DK (Denmark), EE (Estonia), ES (Spain), FI (Finland), FR (France), GR (Greece), HU (Hungary), IE (Ireland), IS (Iceland), IT (Italy), LI (Liechtenstein), LT (Lithuania), LU (Luxembourg), LV (Latvia), MT (Malta), NL (the Netherlands), NO (Norway, PL (Poland), PT (Portugal), RO (Romania), SE (Sweden), SI (Slovenia), SK (Slovakia), TR (Turkey), UK (the United Kingdom).
Source: EEA, 2014.

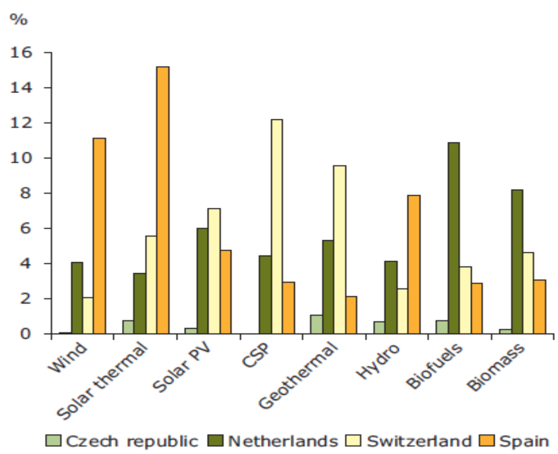
In all the four countries the key driver for innovation in the RES sector has been the availability of targeted budgetary funding for R&D. In the Netherlands, for example, funding allocation can be ascribed to the specific demands of (mostly larger) private industry players that worked through innovation contracts. In addition, in the Netherlands, the existence of a strong PV cluster in the south-east of the Netherlands (Limburg and Noord-Brabant), comprising producers, suppliers and equipment factories, has spurred successful R&D in solar PV. In comparison, Switzerland's strong point in solar technology could be linked to its existing technological capabilities in this area, while its forte in geothermal stems from its relatively high domestic potential for geothermal energy. Spain's leading position in wind and solar thermal may be related to its early mover status in these technologies. By comparison, in the Czech Republic, a number of sectors already exist where skilled labour force and innovation activities has helped spur further innovation in the RES sector, such as electrical and electronics engineering, mechanical engineering, wood processing, and information and communication technologies. Further, environmental awareness has been high in the Czech Republic, leading to the setting up of technological parks and business incubators for eco-friendly technologies.

Figure 8: Patent Applications Per Capita *versus* R&D Budgets Per Capita in Select Countries



***Note*:** For country codes, please *see* refer to note attached to *Figure 7*.
Source: EEA, 2014.

Figure 9: Share of RETs Patent Applications in the Total Patent Applications of EU-27 and Switzerland between 2006 and 2010



Source: EEA, 2014.

3.3 Key Lessons Learnt

According to IEA (2008) and IEA (2011), some key points need to be borne in mind in the overall choice and design of support instruments for effective and efficient RE deployment. That is,

- FITs/FITPs have observably had their impact on RE deployment in varied situations. For FITs, support levels can be customized, and combined with regular built-in tariff reviews to avoid over-compensating investors as costs reduce over time. This is especially true for modular technologies with short development times and high learning rates (such as solar PV), for which built in mechanisms to avoid explosive growth (via a capacity or expenditure cap) becomes necessary. FITs do not expose the technologies to the direct competitive market with other technologies. They are, therefore, well suited to technologies that are somewhat away from being competitive. Implementing a feed-in system in the form of a premium on top of electricity market prices can be used to expose technologies to competition.

- TGCs are also known for being effective in stimulating RE deployment. In this case, deployment volumes and prices can be regulated via caps, buy-out fees, and price floors and banding. These regulations, however, are beset with the risk of over-rewarding some technologies. In general, given the overall nature of support, TGCs are most suitable for the more mature technologies that are approaching competitiveness and as a market-based mechanism.
- Competitive bidding/ tenders offer high security to project investors once the bid has been won. In the initial phase of project development, however, tenders are uncertain for investors, which could pose a hindrance, especially for smaller developers. The advantage of bidding is that it permits competitive price discovery and, therefore, provides an opportunity to bring forward quantified levels of deployment at a low cost in the context of the local market. It is believed to be best suited for mature technologies that are on the verge of being competitive.
- Grants provide a less complex instrument to stimulate RE deployment, but it is perhaps most appropriate for technologies at or just leaving the demonstration stage, and for deployments at a limited scale. Grant schemes are often constrained by budgetary changes, and thus fail to provide the long-term market certainty needed to develop an established supply chain capability.
- Tax incentives measures provide poor management of deployment volumes and prices, and wield little or no pressure on developers to control or reduce costs. They too are sensitive to budgetary constraints and may cause a stop-go deployment pattern that is not conducive to sustained growth in RE deployment.
- Evidently, a high level of RE deployment encouraged by public support measures does not necessarily result in a sound and steady innovation process. On the contrary, too effective (and too generous) policy support may not stimulate cost reduction via technological innovation, but rather culminate in high levels of deployment at high costs, as witnessed in the case of Czech Republic and Spain. Factors such as R&D budgets coupled with a strong national innovation policy and industrial base to support technology development and deployment are equally important for innovation in the renewable sector.

4. Country Case Studies

4.1 The Case of FITs and Emergence of PV Bubbles in Germany and Spain

A number of countries that have relied on FITs/ FITPs as the dominant measure of support for RE deployment have witnessed larger than expected amounts of installation of solar PV capacities. These unexpectedly large and booming PV markets have posed a difficulty for policy makers and stakeholders in terms of the cost support policies. The case of the PV boom in Germany and Spain is illustrative (*see* also *Table 8*).

Germany has been supporting solar PV growth at the regional and national level since the early 1990s by relying on a range of policy mechanisms. Germany managed

PV volumes for much of the last decade by utilizing pre-determined rate decreases. The most recent breakthrough in policy space has been the introduction of PV rates that decline progressively based on the amount of capacity installed in the prior periods. That is, the price paid for PV per unit is now linked to the PV market volume. As observed by Fulton (2011), from an investor's perspective time triggered automatic rate adjustments based on volumes, whose circulation formulae are transparent and methodically grounded, best deliver the triple features of transparency, longevity and certainty (TLC). When combined with transparent, periodic reviews, such adjustments can render the flexibility deemed to support policy longevity. Thus, after relying on the hard caps for its PV FIT policies of 1990s and early 2000, the German government has since relied on strategies for limiting (enabling), market growth by regulating the FIT price levels. For instance, there was only a single rate available for PV technology during 2000-2003. Starting with 2004, Germany introduced PV rates that were differentiated by size (e.g. capacity) and by application (e.g. façade integrated or free standing).

Germany managed to consistently exert a downward pressure on solar PV prices through degression during the past decade, in response to significant acceleration in market growth. During 2000-09, degression was set as a fixed annual amount. During 2009-11, however, the German government introduced a volume response "corridor" or "flexible" degression schedules. During 2010 and 2010, the government also implemented the concept of "non-scheduled adjustments" as a result of unforeseen developments in the prices of PV systems. It was observed that since 2008, PV component prices declined sharply, with panel prices falling around 40 per cent in 2009 alone.

Due to the well managed price degression followed by Germany, the scale of the PV sector transactions costs - including grid connection fees and installation- were significantly lower compared to the other European countries. Thus, the use of price to control volume rather than putting hard caps on volume was a strategy which really nailed the success of FIT for PV in Germany.

Spain's FIT policy was kick-started with the Electricity Sector Law of 1997 (Law 54/1997) with the very first amendments ushered in 2004, when a target of 150 megawatts (MW) for solar PV was established. It was envisaged that once the target is attained, the support levels would be adjusted. This policy change came under criticism from the RES generators, who argued that the annually revised support levels were not transparent and raised the risk for investors, thus causing high risk premiums being charged from them by the lending institutions. In 2007, post detailed negotiations with investors and developers; the Royal Decree 661/2007 was promulgated leading to a marked impact on Spain's solar PV sector, which delinked the FIT rate from the Average Electricity Tariff (AET). This is because as the AET rose between 2005 and 2006, the cost of RES-E support also rose, forcing the government to undertake policy reforms. The other main features of RD 661/2007 were: revision of FIT rates scheduled for every four years, establishment of mandatory guarantees to prevent speculation, RE to receive priority access to the electricity grid, evolving a long term energy plan (2011-20) and putting in place a cap-and-floor price system.

An immediate fall out of this policy change was a sudden massive spike in PV delivery in 2007 and 2008, due to the generous FIT. Initially, there was a steady but low rate of installation up until 2006, followed by a sudden spike in deployment in 2008. However, later a reduction in support led to a subsequent plummeting of installations to zero in the following year. By 2009, the total annual cost of subsidizing solar PV was US $2.6 billion per year. At this level of expenditure, solar PV subsidies represented over 50 per cent of all RE spending, despite producing a mere 12 per cent of all renewable electricity generation, and only 2.45 per cent of total electricity generation. This was ruined as the government stepped in to reduce the costs of the FIT. This angered the investors and the failure on part of the government to control costs damaged the future prospects of taxpayer-funded solar PV delivery in Spain and lost the faith of the investors.

The poor design of FIT was one of the main reasons for its failure in Spain that included:

- An over-generous rate structure of FIT, especially in 2007
- No subsidy degression initiation with the falling cots of the solar PV projects.
- Extremely long period of transition to policy schemes when tariff reduction was expected.
- A lag in the reporting of investments by regional government.

The government basically failed to lower the compensation in response to the rapidly declining costs on account of technical change and learning. Additionally, the investors were able to install the solar PV, which is a modular technology, in a short time span while the policy makers were not able to react to the changing conditions at the same rate. The slower internal communication within the government machinery caused delays in communication to the national government to make them aware of the scale of regional investments, and the crisis had already hit.

The final outcome was lose-lose situation for all stakeholders. The electricity system was burdened with costly solar PV generation. The policy changes had repercussions for the ongoing viability of the industry, with solar PV developers losing faith in government's retroactive tariff changes. Numerous companies associated with solar PV manufacture either had to close down or undergo a merger, and employment in the sector fell from a high of 41,700 reported jobs to fewer than 10,000 in 2012. In fact, the recurrent policy changes had far reaching implications for RE sector as a whole, damaging the investor confidence in the reliability of Spanish policy framework.

Table 8: Experience with FITs in Germany and Spain: A Comparison

What Germany did	What Spain did
Used price to control volume (**no hard caps**)	**Overcompensated** solar PV
Increase in solar PV delivery with a **fall in FIT costs**	**Exponential** growth in solar PV deployment with a corresponding **growth in costs of FIT**
FIT degression options- degression was automatic and transparent	**No subsidy degression** options- transition period between revisions of FITs were too long
Initially a fixed degression followed by a flexible degression schedule	Rise in prices of Solar PV subsidies
Active policy makers and **political consensus** in tune with investor's needs	**Slow reaction** by the government in turn hurting investor confidence
Adopted **triggers, adjustments** and most important **review** concepts and how it impacts TLC	Should design a policy that **avoids cost crisis**, develop tracking methods so that government can **detect and react** to problems promptly and try to **limit damage** in case of crisis
Increased employment and trade in international market of solar PV	Domestic **job losses** and contraction in international market
Merit Order Effect (MOE) took place	No MOE took place
Germany is world's dominant solar energy market	The solar energy market failed in Spain

***Source**:* Authors' construction based on Fulton, 2011

4.2 The Experience with Auctions in Brazil

Electricity auctions have occupied centre-stage in the regulatory framework adopted by Brazil when it embarked on reforming its electricity sector in 2004. Since then, regular operation of energy auctions has resulted in construction of 58 GW of new generation capacity (of which 46% is hydropower and another 29% is RE based), through about US $350 billion in long-term contracts. Wind energy auctions have, in particular, progressed in two phases. The first stage was marked by a strong policy determination to promote the development of non-conventional RE sources, in the pre-2013 period, in order to diversify the primary energy supply mix in favour of small hydro, wind, and biomass energy. In this stage, contracts were tailored to individual technology features, so that more investment could be attracted while insulating the investors from risks—such as inflation and uncertainty of variable generation. Consequently, the result was a humungous success with RE auctions that managed to attract large amounts of investments from both the public and private sectors, and allowed consumers to benefit from cleaner energy at cheaper costs. However, this was criticized on the ground that the terms offered in contracts were too generous for investors and that, as a result, generators had an incentive to bid aggressively and to give unworkable guarantees about their plants' anticipated performance. With security of supply in mind, the second stage of wind power development with auctions was ushered in 2013 with much needed revisions of some key aspects of the auction design now seeking an optimal allocation of risk in the contracts offered to wind producers.

So far, Brazil has adopted two types of auctions schemes for deployment of RE: technology-specific auctions and reserve energy auctions. Technology-specific or project-specific auctions are used to deploy new capacity and supply the regulated market, when the auction has been targeted to support specific energy policy decisions or the introduction of special projects (such as large hydroelectric plants). In this case, contracts have to procure Firm Energy Certificates (FECs) to ensure that new power production is added to maintain minimum adequacy and reliability levels at the system level. Reserve energy auctions, by contrast, are carried out to directly increase the system's reserve margin, and contracts need not be covered by FECs.

Several points are noteworthy about the Brazilian experience with auctions for RE. The performance of RE procurement through reserve auctions has been relatively better than through technology-specific auction. The lacklustre performance of the latter can be attributed to: ability of RE developers to obtain higher prices in the free market on account of the attractiveness of the T&D discount, general difficulty for RE to comply with FEC coverage obligation, since intermittent generation tends to face the risk of penalization, finally, the upper limit for the remuneration level in the auction was set at a rate lower than that allowable under the PROINFA (the early policy framework on RE promotion). In comparison, the reserve auctions have emerged as a more promising option, as these carry lower risks for the investor. As of today, three rounds of reserve energy auctions for RE have been initiated (August 2008, December 2009, and August 2010), providing a total capacity of about 6.2 GW in small hydro power, sugarcane bagasse cogeneration, and wind-based generation for delivery during 2008 and 2015, and with contract terms ranging from 15 to 30 years (Azuela and Barroso, 2011).

Secondly, auctions have resulted in huge price reductions on account of competition between national and international companies. As compared to the PROINFA period, prices fell by nearly 45 per cent in the 2009 auction alone, and then they fell by almost a further 40 per cent in 2009-2011.Thus, wind farms' participation in the regular new energy auctions over the past few years has contributed to bring down the price of new generation in Brazil as a whole. From the history of all the auctions in Brazil since the 2004 it can be inferred that, between 2005 and 2009, auctioned prices that had been stable at around 80 US$/MWh, after 2011 fell and stabilized around a lower value of 50 US$/MWh. Thus, Brazilian wind energy auctions contributed to enhanced competition in conventional energy auctions, driving down investors' profits and allowing consumers to capture the benefits of lower energy prices (Azuela et. al, 2014).

Thirdly, however, concerns have been raised with regard to the impact of competitiveness of the bids on the sustainability of the Brazilian wind auction mechanism in the future. Given the regular financing conditions and given investment and operation costs, bids in the most recent auctions have been below the level that could sustain the wind power supply chain, thus compounding the risk of construction delays or defaults by the winners that placed unrealistic or adventurous bids.

Fourthly, a phenomena associated with the wind energy based auctions is Brazil is that these have prompted the participation of new equipment suppliers in the wind energy market. In addition to Wobben Wind Power, which has been present in the market for many years (a subsidiary of German company Enercon), IMPSA (Argentinean), Suzlon (Indian), Vestas (Danish), Siemens (German), and GE (United States) are now operating -- or in the process of commencing operations—in Brazil (Azuela and Barroso, 2011).

Lastly, the Brazilian government's recent strategy of adopting tight ceiling prices seems opposed to the country's past experience, since in the earlier auctions competition among suppliers was the most important factor that led to price reductions below the ceiling. Recently, this strategy has brought in a risk of compromising security of supply if auctioned demand is not met. In fact, the prevailing observable trend of having a marginal price very close to the ceiling price points implies that there has been hardly any competition encountered, with many suppliers dropping out immediately and others simply offering the ceiling price.

In general, auctions appear as an effective market-based instrument for stimulating competition among investors, providing price disclosure while eliciting the optimal amount of investment in RE. The key lessons learnt from the Brazilian experience are (Azuela *et. al.,* 2014):

- Auctions tend to make available stable guarantees to both investors and consumers. Auction winners are assured a steady, long-term revenue stream, while consumers benefit from the security that the optimal amount of renewable energy capacity will be installed.
- Well-conceived auction schemes could spur a country's RE program. By attracting attention from national and international players, well-organized auctions provide an interesting alternative for countries in which the energy market lacks a mature RE segment. In fact, this is why auctions have been popular in emerging economies, such as India and Brazil, where the risk of a few firms exerting too much market power has been a barrier to RPS schemes.
- To allow policy consistency and compatibility, auction mechanisms should be fully integrated with other regulatory, planning, and economic strategies of the country.

- Evidently, auction mechanisms have proved to be very effective in lowering energy prices in Brazil, China, and India, when compared with the levelized cost benchmarks calculated on the basis of "reasonable" assumptions (which are generally used to ascertain an auction's ceiling price and price levels for FIT programs).
- Discouraging overoptimistic behaviour has been a major challenge of past implementation of auctions. Commonly, delays in construction and underperformance have been identified as key systemic problems with auctions. Although these problems can be dealt with to some extent by stiffening penalties for failing to meet the original objectives, it does seem that more often than not, winning the bid represents a best-case scenario rather than a most probable one. Policy makers should be aware of this risk seek to build mechanisms that would provide early warning of potential problems, so that mitigation measures can be taken at the earliest possible stage.

4.3 United States' (USs') Production Tax Credit Program (PTC)

USA has one of the largest PTC programs. The need for a secure, supply of home-grown energy source to power the nation led to introduction of PTC in US. A PTC aims at incentivizing RE production and provides tax benefit against the amount of RE actually produced and fed into the grid. According to the American Wind Energy Association, this performance-based incentive has helped the US wind industry to lead the clean energy market. It rewards producer on the basis of actual energy produced, increases the rate of return to the investor and reduces the payback period as well. PTC has often been preferred over investment incentives because the latter cannot promise installation at optimal level, whereas production incentives encourage optimality as well as sustainability in the industry (Sawin, 2003).

PTC was first implemented in US as a component of the Energy Policy Act of 1992 and, in combination with the renewable electricity standards, has been the main driver of wind power development in US since then. PTC covered wind and bio energy resources. PTC provides a 2.2 per cent per kilowatt hour benefit for the first 10 years of RE facility's operation. In order to avail this, the wind energy equipment should be located in US and energy produced should be sold to an unrelated party only. The unused credits can be carried forward for up to 20 years following generation[14]. The installation of wind capacity at large scale in Texas along with introduction of US Federal PTC has made wind energy competitive. The US department of Energy quotes that US wind capacity has more than tripled during 2007-12, and the costs of generating electricity from wind have fallen during this period. But lapses in the policy have led to a dramatic slowdown in the planned wind projects, which affect the further growth of industry. While short term PTCs are less likely to induce adequate R&D, long term policy of PTC can spur positive growth in R&D and innovation. Short term PTCs expiring soon lead to hurried investments with small installation capacities and thus high electricity costs.

The main issue with the US PTC for wind energy has been that it has been allowed to expire several times intermittently, leading to cycles of boom and bust in the market, which in turn have led to suspension of projects, worker lay-offs, and loss of momentum in the industry. This approach of halting and then restarting of policy has posed a challenge for the US industries (Sawin, 2003). Long term extension of PTC could

[14]Renewable Electricity Production Tax credit, Database of State Incentives for Renewables and Efficiency, DSIRE, North Carolina State University, 2011

help development of RE capacity by bringing stability in the wind energy sector. This would also aid in bringing wind energy at par with fossil fuel and nuclear power industries which have enjoyed incentives for long periods[15].

The American Wind Energy Association reports that PTC fosters economic security as the price of wind power has dropped by around 43 per cent over the past four years (2008-2012) benefitting the consumers as well as utilities (AWEA, 2013). According to the US Dept. of Energy (2013), there are over 550 US wind equipment manufacturing facilities across 43 states and for the past five years, this industry has been driving $15 billion of private investment on annually.

The lesson learnt from the US experience in respect of PTC is that frequent expiration of the policy have created uncertainty in the industry, which has posed a challenge to development of renewable energy and this could be corrected by appropriately timing the extension of PTCs which can cater to the issue and provide for continued expansion and economies of scale to persist.

4.4 Denmark: The Case of a Leader in Innovation in RETs

The patent activity is a significant measure of a country's level of specialization in certain technologies and of future potential for market share growth. From the analysis presented in *section 4.2.4*, it is evident that Denmark is a clear leader as far as the number of patents filed in RETs as compared to other countries is concerned.

Denmark (besides Germany and Japan) can be termed an established RE market leader that has long placed its industrial and economic development objectives at the heart of its support for RETs (IEA, 2011; Jochem *et al*., 2008; Mizuno, 2010). Denmark has promoted the creation of effective industrial clusters and developed vibrant home markets by instituting stable, enabling policy frameworks along the innovation chain, besides creating favourable investment conditions for innovative RETs, including solar PV and wind. It has specialized at an early stage in the supply of new RETs that were embodied with high knowledge intensity and learning potential, and thus the country has emerged a front-runner in terms of RE innovation (IEA, 2011).

On 22 March 2012, Denmark witnessed the signing of an agreement amongst the major political parties, which set the institutional structure for a changeover to a green and sustainable energy economy in the country. One of the provisions of the framework was large investments in RE and energy efficiency up to the year 2020 (in the range of DKK 90 million to DKK 150 billion). In addition, the energy agreement also set the stage for the need for a continued intensive RD&D of new green energy technologies. However, this is not a new development. Denmark has been consistent in implementing sustainable energy concepts over the years, and it is now very advanced in achieving a sustainable energy system through increased energy efficiency and the share of renewable energy as well as the integration of energy networks (electricity and heat but gas as well is being considered) Furthermore, Denmark has had a very favourable environment for innovative clean-technology start-ups (EEA, 2014).

[15]Union of Concerned Scientists (Based on data from US Dept. of Energy and American Wind Energy Association)

A closer look at patent applications in Denmark shows that most of the patents are in wind energy technologies. Wind power made available over 30 per cent of electricity production in Denmark in 2012, and this is expected to rise to around 50 per cent by 2020. Moreover, historically, Denmark has been a pioneer in developing commercial wind power during the 1970s, and today a substantial share of the wind turbines around the world are produced by Danish manufacturers such as Vestas and Siemens Wind Power along with many component suppliers (EEA, 2014).

The key lesson to be learnt from Denmark is that its current position as a front-runner in innovation in RE can be ascribed to the bold political decisions to transform the energy system, the early mover advantage in wind energy, and a favourable climate for innovative start-ups. The relatively low costs of patent applications and the opportunity to apply for patents in English language may have also played a favourable role in this regard (EEA, 2014).

4.5 Experience with FITs in Indonesia

RE development plays a very small role in the Indonesian national energy supply, accounting for only around 6 per cent of the total final energy supply. Most renewable energy comes from geothermal, hydro and biomass power. The country's geothermal resource is estimated at around 28 GW of capacity; about 40 per cent of the world's known potential. At the moment, the installed capacity is less than 1.2 GW, only around 2.7 per cent of Indonesia's total installed power capacity in 2011 (Warnika, 2012). Several independent power producers (IPPs) operate geothermal power plants in addition to the plants operated by PLN. While the cost of geothermal is low, high upfront capital requirements have hindered development. Hydropower is also estimated to have the potential to reach 75 GW. Currently, only 7 per cent of this has been developed, mostly by PLN, but with some plants operated by private power companies (Warnika, 2012).

Indonesian Presidential Decree 26/2006 set a target for RE at 17 per cent of the total energy mix by 2025, which was revised in 2010 by the Ministry of Energy to up to 25 per cent. Several policies have since been introduced to support RE development. The most recent is a new regulation setting out a feed-in tariff for renewable electricity. This requires the National Electric Company (PLN) to purchase renewable electric power at pre-decided prices (*Table 9*).

Another support measure apart from feed-in-tariff available to RE is a guarantee for PLN's business viability for power projects operated by IPPs for energy technologies specified under PLN Fast Track II program. It is available to all RETs, but since the program covers only large projects, geothermal and hydro projects get the benefit.

The feed-in tariff is set by the government at the outset of the project with an assurance that PLN will take all the electricity produced by the power plant in question. This price certainty reduces the risk associated with recovering investment and operational costs. A guarantee of this kind is particularly important in Indonesia, where the PLN's domination of transmission and distribution makes the electricity market a monopsony (buyers' monopoly).

As of 2012, the government of Indonesia has introduced FITs for the purchase of electric power generated from various renewable sources (*Table 9*). To encourage use of

RE by smaller-scale power plants, the government has introduced FITs for mini and micro hydro power, biomass and waste power plants. The FITs vary depending on technologies, location and whether the supply is connected to a low/medium voltage network. Connecting to a medium voltage network fetches a lower tariff rate (Rp 656/ kWh) than connecting to a low voltage network (Rp 100/ kWh). This can be problematic since interconnection with a low-voltage network tends to be unstable if there is a high-voltage fluctuation, which may adversely impact the performance of power plants. Other measures to promote the use of solar power, including feed-in-tariff and purchasing arrangement for small scale users, are currently under consideration ("TarifListrikTenaga," 2012).

Table 9: Feed-in Tariffs in Indonesia from different Energy Sources

Energy Source	Feed-In Tariff	Conditions
Geothermal	U.S. cent 10–18.5/ kWh	Depends on location, and whether the power plant is connected to a high- or medium-voltage network.
Mini and Micro Hydro	Rp 656–1,506/kWh	<10 MW; depends on location and whether it is connected to a low/ medium-voltage network.
Biomass	Rp 975–1,722.5/kWh	<10 MW; depends on location and whether it is connected to a low/ medium-voltage network
City Waste	Rp 850–1,398/kWh	<10 MW; depends on the technology utilized and whether it is connected to a low/ medium-voltage network

Indonesia has also introduced a 'bidding mechanism' that facilitates awarding construction rights and higher tariffs to specific developers. While there has been progress due to these incentives, problems have also been experienced due to the co-existence of bidding mechanism and feed-in-tariffs. The government had to annul the outcome of some bidding processes for geothermal projects because the winning bids demanded a power tariff higher than the rate set by the government's feed-in-tariff level. In all these cases the bidding was conducted by the local governments[16] where the project had to be located. This is attributed to the lack of technical capacity and/ or conflict of interest that may exist—local governments have an incentive to allow bidders to set higher feed-in tariffs, as they receive royalties from renewable power projects operating in their jurisdiction.

The key lessons learnt from the Indonesian experience were:

- Lack of coordination and conflict of interest between different tiers of government institutions could adversely impact the pace of RE development.
- Technical issues based on interconnection with grid might need to be given due diligence before arriving at the tariff rates based on the scale of the renewable energy plant.

[16] Since the decentralization process began in Indonesia in 2001, some authority over investment procedures and related government revenue has been transferred to regional and local governments. Regional governments, for instance, have the right to determine the site of business activities following their local development master plan. Often, investors that have secured permissions from the central government will need to re-evaluate their plans in order to comply with regional and local governments' requirements, or even totally cancel them (Pambudhi, 2006). Local governments' may also hinder or promote investment decisions through regional fiscal policies, such as local taxes and levies or local subsidies.

4.6 Renewable Energy in India

India has a well-diversified portfolio of regulatory policies as well as fiscal incentives and public financing for RE development and deployment. These include feed-in-tariffs, renewable energy portfolio, tradable RECs, production tax credit, tendering, net metering, and capital subsidies among others. It represents the world's 6th largest RE market (REN 21, 2012). According to the Global Status Report, 2014, India is among the top five countries investing in hydropower, concentrated solar power, wind power, and solar water heating capacity. It is also among the top nations for total capacity or generation of renewable power (excluding hydropower) as at the end of 2013. The country plans to double its RE capacity from 25 GW in 2012 to 55 GW in 2017. The national targets for RE are set in consonance with the National Five Year plans as well as the National Action Plan on Climate Change (NAPCC). In order to overcome the cost barriers, fiscal incentives are being provided like the Generation Based Incentive (GBI) scheme which pays USD 0.01/kWh to producers (Global Status Report, 2014).

Most of the states are complementing reverse bidding program with a feed-in-tariff as a ceiling cap for tariff rate for solar PV. For wind projects, feed-in-tariffs are taken up without bidding programs. These are facilitated with the help of Jawaharlal Nehru National Solar Mission (JNNSM) laid by NAPCC and state government policies. Due to the efforts of JNNSM, the solar PV power capacity has risen from 8MW in 2010 to 1200 MW in 2013. In addition to this, prices fell from 35c/kWh to less than 17c/kWh due to reverse bidding process making the renewable sources in comparison with fossil fuel based energy (EEW and NRDC, 2012). As in South Africa, here as well, civil society plays a pivotal role in bridging the information gap regarding cost of various RETs (WRI, 2013). In solar PV industry, manufacturing units operate at low or idle capacity because of less competition reason being lack of scale, low cost financing and underdeveloped supply chains. With regard to the weak enforcement and on-compliance issues in implementing RPOs amongst states, the Ministry of New and Renewable Energy plays an active role to check any misconduct (Parihar, 2012).

JNNSM is considered to be the most successful policy toward the deployment of RE but the domestic content regulation in solar manufacturing industry attracted strong criticism because of its ineffectiveness. Also the facilitation of RETs is limited to a few states, which restricts the scope for their expansion. Policies and targets vary across states and the Central Electricity Regulatory Commission plays a key role in deciding where the projects should be based. Despite the rapid growth in the RE deployment, India continues to face challenges because of the lack of transparency, accountability and grid infrastructure facilities (WRI, 2013). Insufficient trained manpower, weak transmission networks; delays in payment by DISCOMS also pose challenge to the growth of RETs (Government of India, 2006 and MNRE 2012c). Improvements on these fronts can increase investor confidence and governance thereby enhancing scope of RE in the country.

4.7 Best Practices and Experience with Specific Instruments

According to the European Commission (EC, 2013), the best practices as regards cost calculation in the design of the select policy instruments, with special reference to in-built flexibility and timing/ phasing-out aspects of the incentive/ support measure are compiled in *Tables 10* and *11* below.

Table 10: Guidelines for Best Practices in Cost Calculation, Automatic Tariff Degression and Determining Time Frame of Support

Aspect of Regulatory Process	Best Practice
Cost elements and calculation methodology	- Reliance on competitive allocation mechanisms (to the extent possible) to force market players to reveal their real production costs - Cost base calculations to be based on project costs, and to include the following cost elements: o Equipment cost; other investment and planning costs; cost of land; o Administrative costs; operation and management costs; fuel costs (if relevant) o Common cost assessment for grid connection / grid reinforcement; -network-related costs; costs of market integration - Expected revenues: o To be calculated in advance o Adjustments ex-post for differences between the agreed, expected revenues and actual revenues, to avoid over compensation o Technology specific load factors - Caps and floors influencing the level of support to be should be linked to the above cost analysis. - Determination of support levels based on levelized cost estimates
Automatic tariff degression	- Periodic review and adjustment of support levels for new installations o Process of review to be defined ex-ante and be automatic o Determine what constitutes excessive growth and set a volume limit defined in budgetary terms if expenditure is the policy constraint motivating such a cap
Time frame for support	- Limiting support to comparable periods (10/15 years)) or to a pre-set number of full-load hours calculated based on reasonable expectations for capacity utilisation over a defined period. - Longer the time frame, greater the need for flexible, market-adapting instruments

Source: EC, 2013

Table 11: Best Practices in the Design of Select Policy Instruments

Incentive/ Support Measure	Countries where the Instrument is Used	Best-practice Recommended
Feed-in-premium	Canada, Netherlands, Spain	- Preference for feed-in-premiums over feed-in tariffs for technologies getting mature - Determining the form of premium - floating (with or without cap) or fixed – as function of desirable exposure of producers to price risk - No payment of premiums for production in hours where the system price is negative or above the level of remuneration deemed necessary - Use of competitive allocation mechanisms to the extent possible for granting premiums - Planned volume based premium reductions for new installations, dependent on when they are approved, connected or commissioned - Regular reviews of premiums for new installations
Feed-in-tariff	Canada, China, Germany, India, Italy, Spain	- Phasing out of feed-in-tariffs - Need for built-in cost-based or expected cost-based tariff reductions for new installations (in line with learning curves and expected future cost reductions in various technologies) - Planned volume based tariff reductions for new installations, dependent on when they are approved, connected or commissioned
Renewable portfolio standard	Italy, Japan, UK, US	- Technology neutral schemes that promote cost efficient deployment or banded schemes to avoid over compensation of cheapest technology and to reflect explicit technology innovation and

		diversification goals - Schemes based on long-term transparent and planned quotas - Adequate non-compliance penalties to be built in
Competitive bidding	Brazil, Canada, China, France, India	- Tender for support with clear rules that foster genuine competition between bidders - Tenders can be used to allocate different instruments such as feed-in premiums, investment support or green certificates - Tenders need to ensure delivery, e.g. via penalties

Source: EC, 2013 and Authors

5. Conclusions

The issue of design and implementation of support measures for RE technologies is complex and require a nuanced, case by case approach. However, some broad conclusions can be drawn from a review of design and implementation of such measures discussed in the foregoing sections.

Foremost, the design of the support instrument needs to be placed in a specific policy context (e.g. energy and climate policies), with clear identification of drivers for and barriers to its design and deployment. The role of the regulatory, institutional and political environment needs to be emphasized, especially as the level and structure of the instrument have to be benchmarked against the prices of conventional energy, besides other advantages that conventional energy sources enjoy (e.g. supporting infrastructure, consumer acceptability, established technology and such like). The cost of RE, as much as the grid based prices (and more recently the presence of carbon taxes), has a bearing on the viability of RETs. There is widespread recognition of availability of and connectivity to grid infrastructure as a constraint to diffusion of solar and wind power across a range of country studies.

Political will and incorporation of RE targets in the national policy framework are important to introduce and effectively implement policies on RET dissemination. China with its strong manufacturing base and aggressive incentive mechanism has clearly emerged as a world leader. Time bound objectives along with complementary policies towards diversification have been the mainstay of policy in China. In Germany as well, policies concerning RETs have been an integral part of the industrial development policy. Complying with international environment treaties helped Canada establish markets for RES-E. For India, both political resolve and need to comply with international treaties were the driving force. The French FITs suffered because of complicated administrative and planning procedures.

Policy support measures have been affecting the cost effectiveness of technologies by giving stimulus to RES. A significant impact on innovation could not be found for a large set of countries. The exception being Denmark, wherein, a large number of patents were filed. Germany, Spain, and USA (especially California and Minnesota) have had fully mature markets, which could be ascribed to the support schemes in RES-E sector that have helped in significant cost reductions.

In general, it has been found that price-based instruments have worked better as compared to quantity-based instruments, and amongst various RES, wind technology has had the maximum potential for cost reduction and dissemination. It is also commonly suggested that incentives/ support measures need to rely, as much as possible, on market based instruments, e.g. quota obligations coupled with tendering and/ or green certificates, such that the true costs get revealed. A caveat that is put forward in this regard is that reliance on market forces will circumscribe the ability of the producers to reap the sufficient rent that can otherwise help spur innovation. Thus, incentives for dynamic efficiency for less mature technologies (in particular) should not be ignored.

None of the instruments offer an optimal solution in all the evaluation criteria. As a consequence, governments will have to select an instrument and sustain it in the long run in accordance with the relative importance of its objectives. In a complementary way, conditions of a successful instrument vis-à-vis the regulatory risk include long-term government's commitment, foreseeability of the instrument and ex ante flexibility to capture decreasing RE cost and correct redistributive effects. The level of the support must not be abstracted from the incurring risks and transaction cost.

The costs of RETs tend to fall as there is learning-by-doing and market maturation. Thus, the instrument design needs to have in-built flexibility in the price or quantity domain so as to adapt to the changing market situation. In this regard, a smooth phasing out/ exit policy for the RE technology is also prescribed as the levelized cost of the technology is lowered to approach that of conventional energy in the limit. With respect to the best practices for specific instruments, feed-in-premiums help in achieving low costs and innovation. FITs help in insulating the new market entrants by reducing the cost of capital thereby encouraging investment. Competitive bidding, being a self-regulating instrument has a built-in phasing out mechanism. It can be concluded that an instrument is appropriate when it is able to adjust flexibly according to technology learning, and has built-in revision mechanisms with respect to the global market scenario. A suitably designed phase-out plan for the support scheme would alleviate the need for authorities making ad hoc administrative revisions of the existing scheme in terms of its scope, level and the time frame and avoid undue burden on government budgets.

Annexure A

Review of Stated Energy RD&D Priorities for Governments Based on Announced Technology Programs or Strategies

Country	Name of Programme or Strategy	Programme or Strategy Priorities	Share of RD&D Spending on Priorities	Do stated Priorities and Actual Spending Match?
Australia	Clean Energy Initiative	CCS, low emissions coal, renewable energy (specifically solar)	CCS 19%, low emissions coal 8.3%, renewables 22% of which 14.5% is solar (PV 11%)	Stated priorities account for 50% of total energy RD&D budgets
Brazil	Science, Technology and Innovation Platform for National Development 2007 - 2010	biofuels, T&D, hydrogen, renewables, oil, gas, coal and nuclear	biofuels 14%, T&D 23.5%, hydrogen 2%, hydro 11% and nuclear 23%	Stated priorities account for 81% of total energy RD&D budgets
Canada	Energy RD&D program divided into 9 portfolios	Oil and gas, clean coal, CCS, distributed power, generation IV nuclear, bio-based energy systems, industrial systems, clean transportation, built environment	non-conventional oil & gas 6%, coal 7%, CCS 15.5%, fuel cells 3.66%, EE in industry 3.22%, EE in the transport 2.5% and nuclear 29%	Stated priorities account 67% of total energy RD&D budgets
France	National Strategy for Energy Research 2007	nuclear, renewables, fuel cells, energy storage, CCS, EE in buildings, biofuels, low carbon vehicles	nuclear 50%, renewable energy 11%, fuel cells 3%, CCS 4.5%, EE in buildings 3%, and biofuels 4.5%	Stated priorities account for 80% of total energy RD&D budgets
Germany	Innovation and New Energy Technologies 2005	CCS , PV , Solar Thermal , Wind , Fuel Cells and Hydrogen , Technologies and processes for energy optimized buildings , Technologies and processes for use of biomass for energy	CCS 1%, PV 9%, Solar Thermal 1.3%, Wind 5%, Fuel Cells and Hydrogen 5.1%, Technologies and processes for energy optimized buildings 3%, Tech. and processes for use of biomass for energy 1.32%, nuclear 34%	Stated priorities account for 60% of total energy RD&D budgets
Japan	Science and Technology Basic Plan 2006	energy efficiency, nuclear, transport, fuel cells, hydrogen, solar PV and biomass energy, oil, gas and coal	energy efficiency 10% , nuclear 64%, transport, fuel cells 3%, hydrogen 1.4%, solar PV 1.4% and biomass energy .27%, oil	Stated priorities account for 80% of total energy RD&D budgets

Country	Name of Programme or Strategy	Programme or Strategy Priorities	Share of RD&D Spending on Priorities	Do stated Priorities and Actual Spending Match?
			gas and coal 9.3%	
Korea	Green Energy Strategy Roadmap 2009	PV, wind power, fuel cells, LED, Smart Grids, IGCC, Energy Storage, Clean Fuels, CCS, Nuclear Power, Green Cars, Heat Pumps, Energy efficient buildings, CHP, superconductivity	wind power 6.5%, fuel cells 8.6%, IGCC.1%, energy storage 3.8%, CCS 4.5%, nuclear power 16%, energy efficient buildings 5%	Stated priorities account for over 50% of total energy RD&D budgets
Netherlands	Energy Report 2008	biofuels, clean fossil fuels, renewables, sustainable mobility, industrial efficiency, building efficiency,	biofuels .62%, clean fossil fuels 9.3%, industrial efficiency 13%, building efficiency 9% other energy efficiency including agriculture and horticultural sectors 13%	Stated priorities account for 68% of total energy RD&D budgets
Norway	OG 21 2001 and Eneri 21 2008	Oil and gas, energy systems, renewable electricity, energy efficiency in industry, renewable thermal energy and CCS	Oil and gas 37%, energy systems 4.7%, renewable electricity 15.5%, energy efficiency in industry 2.3, renewable thermal energy 1.2% and CCS 15.6%	Stated priorities account for 76% of total energy RD&D budgets
Spain	National Strategy for Science and Technology 2006-2015	energy efficiency, clean combustion, renewable energy, sustainable mobility, modal shift in transport, sustainable buildings	energy efficiency 8.3%, renewable energy 43%, coal 1%, energy efficiency in the transport sector 1%, energy efficiency in buildings 5%	Stated priorities account for 60% of total energy RD&D budgets
Sweden	National Energy Research Programme 2006	energy systems studies, buildings as energy systems, transport, energy-intensive industry, electricity generation and distribution, bioenergy, CHP	energy systems studies, energy efficiency in buildings 4.7%, transport 22%, energy intensive industry, 8.4%, electricity generation and distribution 7.7% and bioenergy 10.6%	Stated priorities account for 70% of total energy RD&D budgets
United Kingdom			wind 10%, ocean energy 4%, CCS 6%	Technologies where the UK has a leading edge capability account for 20% of total energy RD&D

Country	Name of Programme or Strategy	Programme or Strategy Priorities	Share of RD&D Spending on Priorities	Do stated Priorities and Actual Spending Match?
				budgets
United States	Advanced Energy Initiative 2006	Solar power, biofuels, wind power, hydrogen, buildings technologies programme, clean coal research	solar power 3.5%, biofuels 9.5%, wind energy 1.4%, hydrogen and fuel cells 5.4%, energy efficiency in buildings 2.2%, CCS 4.3% and nuclear 16.2%	Stated priorities of AEI account for 40% of total energy RD&D budgets

Notes: This sample cannot be considered as an exhaustive list, but rather as a showcase of the variety of practices across countries and institutions. Analysis is based on data for the following years: Australia, Canada, Japan, Norway, Spain and the United States: 2007-11; Germany, Sweden and the United Kingdom: 2006-10; Brazil: 2009-10; France: 2007-09; Korea: 2009-11; the Netherlands: 2008-09.

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