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Evaluating renewable energy policies*

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The merits of renewable energy, of targeted renewable energy policies, and appropriate evaluation methods, are each contested at various levels including national politics and in energy policy literature. Here, first a range of renewable energy goals across countries and the policies directed at achieving those objectives are reviewed. Second, the arguments advanced to support use of renewable energy policies in many nations are critiqued. Third, some principles are proposed for design of renewable energy policies. Context always matters, and it is essential to consider energy, economic, and geography opportunities and constraints before developing renewable energy policies. Fourth, to ensure renewable energy policies contribute towards attainment of high-level national goals, a decision support approach is outlined that considers the energy context, and asks a series of evaluation questions to aid identification of first best policy measures. Fifth, barriers to and benefits from implementation of appropriate renewable energy policies are briefly reviewed.

Key words: decision support, evaluation, goals and policies, implementation, renewable energy.

1 Introduction

There is wide recognition that averting the damaging outcomes of accelerated climate change will require rapid switch from heavy reliance upon fossil fuels to alternative, less damaging energy sources. Global investment in renewable power and fuel projects totalled at least USD 301 billion in 2013 (REN21 2015) and contributed strongly to the recent plateau in global CO_2 emissions (IEA 2016). However, much greater levels of investment are essential if renewable energy is to replace fossil fuels as the dominant energy source globally.

There are patchy systems in place around the world, including carbon prices, emissions trading schemes and other mechanisms, which attempt but rarely succeed in signalling to energy consumers the full economic cost of fossil fuel use. Most countries have introduced policies to promote the production and use of renewable energy and to reduce reliance on fossil fuels. REN21 (2015, p. 99) reported that by early 2015, 164 countries had RE targets and at least 145 countries had renewable energy support policies in place. There are many mechanisms that countries can use to promote

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renewable energy production and consumption for the uses listed above. Policy options include regulations and mandates favouring renewables (including bans on fossil fuels), financial support for renewable energy supply and support for renewable energy R&D. Many renewable energy policies have a fiscal cost, their use sometimes imposes economic costs, and their effectiveness is often uncertain. Renewable energy policy is often controversial and several commentators argue that errors have occurred in some renewable energy policy choices (Schmalensee 2012; Helm, 2014).

There are three foci in this paper: the goals sought and policies used to achieve renewable energy targets; the merits of arguments for government policies in support of renewable energy policies; and a decision support approach to assist policymakers considering renewable energy policies. Section 2 summarises the high-level energy and climate change goals countries pursue. Attention then turns to a critique of the arguments for (supportive) renewable energy policies, including policy costs, policy effects and outcomes (Section 4). Opportunities for and barriers to implementation of reformed energy policies are considered in Section 4. Section 5 notes the range of geographic, economic and energy contexts for countries considering introducing RE policies. Key points identified in Sections 3, 4 and 5 are used in Section 6 to develop energy policy principles and a basic decision support framework for policymakers.

2 Goals

Deployment of renewable energy is not an end in itself; its deployment must contribute to some public policy objective (Edenhofer *et al.* 2013). Yatchew (2014) observes that governments strive to balance economic growth, environment protection and energy security goals. Renewable energy supply can potentially contribute to all three of those goals, but what criteria should be used to evaluate policy choices?

Many countries have targeted an increased share of electricity generated from renewable sources and, by necessity, a diminished share from fossil fuels. Growing economies typically face increasing demands for electricity, whether driven by increasing population, increasing incomes, increasing demand from industry or all three of those forces. Renewable energy can help to meet the growing demand for electricity, but users cannot distinguish between electricity generated by renewable sources and electricity generated by burning fossil fuels; there are other reasons for energy policy to favour renewable energy. I identify below nine arguments advanced for promoting renewable energy policies, which are outlined in more detail in Section 3.

1. To offset the subsidies provided to fossil fuels.
2. To offset the advantage provided fossil fuels by the failure to require internalisation of their external costs.
3. To attain health co-benefits by replacing fossil fuel-generated electricity.

4. To increase supply of low-risk energy sources.
5. To achieve green growth and green jobs.
6. To accelerate technological development and achieve leadership in renewable energy.
7. To reduce reliance on imported fossil fuels and increase security of energy supply.
8. In developing countries, to improve access to modern energy supply and reduce network and transmission costs.
9. To reduce energy transmission losses and increase regional energy security of supply.

3 Critique of arguments for renewable energy policies

3.1 Subsidisation of renewable energy to offset the subsidies to fossil fuels

The impacts of a subsidy for renewable energy can be illustrated using a diagram as in Figure 1. Energy price signals in most countries are distorted by government failure (taxation and subsidy policies) and by external costs that are not included in prices. Several studies have defined and investigated the prevalence and magnitude of subsidies for fossil fuel and other energy types (Whitley and van der Burg 2015). OECD (2013a), IEA (2014) and Coady *et al*. (2015) have each estimated the magnitude of subsidies provided to fossil fuel production, but differ in the methods used and subsidy magnitudes estimated. The OECD uses an 'inventory approach' which focuses on direct budgetary support and tax expenditures that support fossil fuel production or consumption relative to other activities or products, but overlook costs of negative externalities. They estimate annual energy

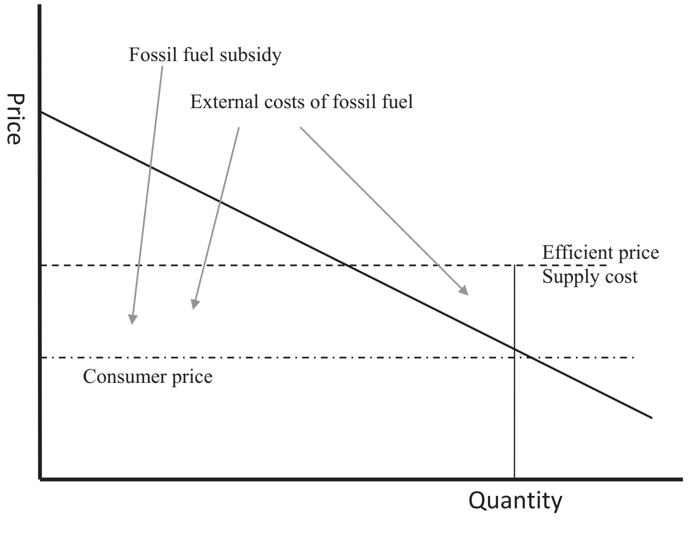

Figure 1 Energy market with consumer subsidies and external costs.

subsidies in 34 OECD countries amounted to \$50–90 billion between 2005 and 2011 (OECD 2013a).

The IEA and IMF both use a price-gap approach, which compares end-user energy prices with reference prices. The reference prices consist of supply cost inclusive of shipping cost and margins and any value added tax. The latest IEA estimate is that fossil fuel consumption subsidies worldwide amounted to \$548 billion in 2013 (IEA 2014). IMF (2015) provides subsidy estimates based on two definitions of energy subsidies. Pretax subsidies compare consumer prices with supply cost, and post-tax subsidies compare consumer prices with supply cost plus the efficient level of taxation which includes an excise component for externalities and a consumption tax component for revenue considerations (IMF 2013). Figure 1 provides an illustration of a subsidy and external costs – pretax and post-tax subsidies under the IMF definition; they estimated that pretax energy subsidies were \$492 billion and post-tax energy subsidies were \$2.0 trillion in 2011.

Climate change and health effects from particle emissions are often large components of those external costs; their magnitudes may differ significantly across countries and between generating sites (Badcock and Lentzen 2010; ExternE 2014). But as discussed in Section 3.2, direct approaches to internalise those costs can provide the most cost-effective means to reduce CO_2 and PM10 emissions (OECD 2013a).

Subsidies for fossil fuel production and use occur in large numbers of countries and strengthen the competitive position of fossil fuels. The simplest and lowest economic cost way to level the playing field for renewable energy is to remove fossil fuel pretax subsidies. Removing a distortion from energy markets will bring multiple benefits including reduced consumption of fossil fuels as their market prices increase, reduced CO_2 emissions from fossil fuel use, increased incentive to improve fuel efficiency, as well as improving fiscal balance for government. Introducing a subsidy for renewable energy is a fiscally costly way to improve its competiveness and often will not contribute to other goals such as energy efficiency.

3.2 Fossil fuels and external costs

The second argument advanced for a renewable energy policy is because the external costs of fossil fuel use are not internalised, fossil fuel prices in energy markets are below their efficient price level, and fossil fuel consumption and CO_2 emissions are larger than their efficient levels. The harmful effects of CO_2 emissions will impact households, firms, nations and the bio-geosphere for many decades. In the absence of intervention, fossil fuel markets do not require these external costs to be borne by energy producers or consumers and thus fossil fuels have an advantage over energy types that are closer to meeting their full costs. Renewable energy, it is argued, has no or much smaller magnitude external costs and is uncompetitive compared to fossil fuel in energy markets. A renewable energy subsidy would increase its market competitiveness, enable it to displace some fossil fuel use and hence reduce the level of CO_2 emissions.

Subsidising renewable energy supply is a second best approach to achieving CO_2 emission reductions (Kalkuhl *et al.* 2013). Direct approaches usually provide the most cost-effective means to redress an externality. Parry (2014, p. 5) comments that a tax on the carbon content of fossil fuel provides incentive for seven responses in economies with diverse energy sources:

- switching from fossil fuel power generation to renewables;
- shifting from coal to natural gas in power generation and to nuclear energy;
- reducing electricity demand through higher efficiency (in buildings, appliances, etc.);
- reducing electricity demand through less use of electricity-consuming products;
- improving the fuel efficiency of vehicles;
- reducing vehicle use; and
- reducing direct use of fuels (e.g. natural gas) by firms and industry.

In contrast, a subsidy for renewable energy generation will incentivise only the first response.

The effectiveness of carbon charge policies in reducing emissions varies with the size of the charge per tonne of emissions (see OECD 2015, figure 16) and the price elasticity of demand for fossil fuels. If both items are small, carbon charges will be ineffective in changing energy usage. However, econometric research on the effects of British Columbia's carbon tax provides clear evidence that a tax of C\$30 per tonne of CO_{2e} is effective at reducing fossil fuel use and CO_2 emissions (Murray and Rivers 2015, table 4).

Tradable emissions permit systems provide an alternative to carbon prices and can be designed to ensure a cap is placed on emissions. If the cap is tight enough to restrict emissions compared to business as usual, tradable permit systems can provide a low-cost way to reduce emissions.

Several studies have analysed the cost-effectiveness of renewable energy policies and calculated the cost per tonne of CO_2 emissions avoided (OECD 2013a,b; Australian Climate Change Authority, 2014; Hughes and Podolefsky 2014; Marcantonini and Ellerman 2014; Holttinen *et al.* 2015). In Australia, modelling of a several renewable energy schemes found cost per tonne $CO_{2\text{-}e}$ ranged between A\$22 and \$95. An ex ante study by Holttinen *et al.* (2015), using carbon price in the range of €10 per t CO_2, estimated the CO_2 avoidance cost of wind power in the years 2007 and 2010 ranged from €56.6/t CO_2 to a maximum of €168.0/CO_2. For the California Solar Initiative, Hughes and Podolefsky (2014) estimated the cost is between US\$130 and \$196 per metric ton of avoided carbon dioxide emissions. For Germany, in an ex post study, Marcantonini and Ellerman (2014) estimated that for wind power for the period 2006–2010, the average implicit carbon price is €57/tCO_2, but for solar the average implicit carbon price for 2006–2010 is €552/

tCO_2. OECD (2013a) estimates 'effective carbon prices' in countries where either explicit or implicit carbon pricing schemes are in place. They find clear evidence to support the economic argument that for a range of instruments in the electricity, transport and household sectors that trading systems and broad-based carbon taxes provide more cost-effective ways to reduce CO_2 emissions, particularly if they are targeted directly at the externality (OECD 2013a, p. 92).

3.3 Fossil fuels and other external effects

Burning coal or wood results in emissions of small particles (pm10) to the atmosphere which can enter lungs leading to increased morbidity and mortality rates. Direct approaches to tackling the health costs (and/or other externalities associated with fossil fuel use such as road congestion) include policies such as bans on dirty fuels, taxes on dirty fuels, congestion charges, energy generation siting policies and requirements for scrubbing to remove particles before emission. Those policies all work directly to reduce external costs linked to fossil fuel. A fiscally costly, second best approach is to provide a price premium for generating clean, low-risk, renewable energy or subsidising renewable energy installations in expectation that renewable energy will displace some fossil fuel use and its associated harmful effects on health. Subsidising renewable energy may be more readily justified if fossil fuel users do not have to meet the full costs of generation or consumption.

Care needs to be exercised because renewably generated electricity, also, may not internalise all of the costs it imposes. Hydroelectricity generation, for example, uses hydropower and requires that water is retained within stream to drive turbines. Dams can have major ecological effects, including interrupting the movement, and even threatening the existence, of some fish and eel species (Doole 2005; PCE 2013). Wind power turbines often have significant landscape effects and can impose costs on nearby residents. They can also have ecological impacts, including killing passing birds, but may not be required to internalise any of these costs. Badcock and Lentzen (2013, p. 5045) note that biomass is second only to coal in the externalities associated with its use for electricity generation.

ECOFYS (2014, figure S6) reports external costs, range and weighted averages, for electricity technologies in EU28 countries. Fossil fuels have large external costs when they are used in electricity generation. External costs for renewable electricity technologies, with the exception of geothermal and to a lesser extent biomass, are much smaller magnitude than are the externalities from fossil fuel-powered electricity generation.

3.4 Riskiness of energy sources

Energy production involves risk to life and worldwide over 2500 people per year lose their lives in direct energy-related accidents (NEA and OECD 2010).

Data are available to determine whether renewable energy is a low-risk source of power, electricity or heat in comparison with other energy sources. Recent evidence (Boccard 2015) indicates that for OECD countries, wind, geothermal, hydro and nuclear have the lowest hazard rates among energy sources in production and fossil fuels have the highest hazard rates. Nations can use appropriate hazard rate data together with information on capital costs, cost per kwh and other information to determine whether they should favour low hazard energy sources.

3.5 Green jobs and green growth

Many policies that governments introduce have local or sectoral employment effects. Policies such as feed-in tariffs, investment support schemes and renewable energy obligations can prompt renewable energy firms to expand their output and employ more labour. Developing new or improved methods of renewable energy generation systems, trialling them, retail sales, installation, operation and management all create employment and contribute to total economic output. Unless there are labour market failures, it is not obvious why job creation in one sector of the economy, or industry development, should be favoured over job creation and industry development elsewhere in an economy, particularly if jobs and economic activity created are simply displacing jobs and economic activity in another part of the energy sector.

3.6 Accelerated technological progress

Nanda *et al*. (2013) argue the government's role is critical in the development of clean energy technologies. Because energy is a commodity and price differentiation is difficult, innovation has to be directed towards lowering production cost. Prices in energy markets are often volatile and most clean energy technologies struggle to reach grid parity, particularly where competing suppliers do not have to meet their full costs of production, or worse, are subsidised by the state. Because energy infrastructure is often large scale and long-lived (hydropower stations last a century or more), technology lock-in may occur. New entrants to energy markets will be at a disadvantage compared to large incumbents using mature technologies which do not have to recover fixed costs or start-up costs. Arguably, there is an infant industry case where government intervention can hasten the rate of technological progress. Governments that are unwilling to leave the rate of technological innovation to large incumbent firms can intervene on both supply (direct grants, tax breaks, taxes on carbon) and demand (feed-in tariffs (FIT), guaranteed market access, net metering), potentially attracting relatively small firms into the clean energy innovation field. Spillover from renewable energy R&D is likely and Schmalensee (2015) argues there is a strong case for state R&D in basic energy research to accelerate the rate of technological advance.

Lins and Murdock (2014, p. 103), argue, ‘The global policy landscape has largely driven the expansion of renewable energy technologies by attracting investment and creating markets that brought about economies of scale and supported technology advances. This, in turn, led to decreasing costs, which ultimately fuel sustained growth’. Some recent US research also sheds light on the role of government in clean energy innovation (Nanda *et al*. 2013; Kerr *et al*. 2014). Innovation comprises many stages including developing, testing, scaling and verifying feasibility, introducing new technologies or processes, some of which are very capital-intensive and require considerable time to complete. Large, incumbent, energy firms have been left to dominate much of the clean energy innovation field. There is some evidence that smaller US firms have made more significant advances in renewable energy technology development than have large incumbent firms (Nanda *et al*. 2013).

Nations seeking to accelerate the rate of technological advance in renewable energy generation should consider the following questions: Which technologies have best prospects for further development (hydropower technology is mature, solar PV technology is youthful, wind power is mechanical, and solar PV is electronic); which stage(s) of research, innovation, introduction can be accelerated by supportive government policies; and would government R&D on renewable energy technologies more effectively accelerate technological advance than would R&D grants or tax credits for private sector firms?

Growing numbers of countries are focused on a broader goal than GDP growth. Aiginger (2014, p. 9) asks larger, more visionary questions about new industrial policy, including where does a country want to be in 20 or 30 years, which factors will define welfare then (income, social goals, ecological sustainability), and which capabilities of a country will provide competitiveness and growth aligned with those pillars? Countries that wish to pursue ‘high road’ new industrial policy should strive to foster competitiveness, skill-rich employment opportunities and sustainability. Arguably, renewable energy policies can be developed and introduced to foster countries’ progress on the ‘high road’.

3.7 National energy security

Most countries are energy importers and, to a varying degree, are exposed to risk of transport interruptions and the need to finance imports of fossil fuels or other energy imports. Increased energy independence is a reasonable goal for any country to pursue, but some quantitative analysis is needed before introducing policies favouring domestic renewable energy generation. An index of national energy security has been developed by World Energy Council (2013) and can be used to assess the impact of national policies. Policies favouring additional renewable energy supply can be justified if they provide cost-effective means to increase national energy security, but are much more difficult to justify whether they are ineffective at increasing energy security or only achieve energy security improvement at a very high cost.

3.8 Improved access to modern energy sources

Over one billion people do not have access to electricity and rely upon traditional biomass to meet their energy needs (World Bank 2015). Small-scale off-grid (distributed) renewable energy systems can provide locally generated electricity and obviate the need and delay before industrial scale electricity is generated and distributed to households (REN21 2015, ch. 5). If targeted policies promoting off-grid renewable energy such as investment subsidies for communities and households provide the most cost-effective way of providing access to modern energy for millions of people in many lower income countries, they should vigorously pursue those approaches (World Bank 2008, Hong *et al*. 2015).

3.9 Increased local energy security

Energy policy may be directed to reducing energy lost in transmission and increasing security of supply by promoting small-scale renewable energy systems close to electricity consumption centres (Barry and Chapman 2009). However, there can be offsets to those putative benefits if increased use of renewable energy contributes to greater instability within electricity networks (Mason *et al*. 2013). Wind, solar and wave power are intermittent electricity generators. Battery technologies are rapidly changing, but electricity is currently costly to store, and intermittent generation can lead to greater amplitudes in supply and increase instability in electricity systems. Greater system instability may offset any gains from reduced transmission losses and more secure local supply that small-scale renewable energy brings. Policies promoting renewable energy that fail to, or even worsen, local energy security should not be pursued.

4 Where next for energy subsidies?

Several commentators (Summers 2010; van der Hoeven 2014) have argued that the recent fall in oil prices, and the consequently reduced energy share in households' and firms' budgets, provides an opportunity to radically transform taxation systems in many countries. Subsidies for energy are rife and predominantly support fossil fuels. They distort energy markets, boost energy consumption and GHG emissions; Stefanski (2014) has calculated that fossil fuel subsidies were responsible for 36 per cent of global carbon emissions between 1980 and 2010. They provide an impediment to the entry of emissions-free renewable energy. Removing fossil fuel subsidies is a direct, cost-effective way to remedy distorted energy markets and will bring benefits of reduced CO_2 emissions and increased opportunity for renewable energy to compete.

IMF (2013) and Whitley and van der Burg (2015) report a number of case studies where countries have reformed energy policies. Many countries have reduced or phased out energy subsidies without severely impacting household incomes and firm survival, sometimes beginning with products consumed by higher income households (petrol) before turning to kerosene and diesel, choosing opportune times when fossil fuel prices are low (Indonesia), phasing changes (Angola, India and Peru) and employing ameliorating policies to reduce adjustment costs (Germany and Poland) (Whitley and van der Burg 2015).

Guidelines for policy reform are proposed by OECD (2013b) and Whitley and van der Burg (2015). Estimates of the benefits – economic, fiscal, human health and environmental – from reform are provided by Coady *et al.* (2015). They estimate that if post-tax energy subsidies were eliminated in 2015, revenue for governments would rise by US$2.9 trillion (3.6 per cent of global GDP), global annual emissions of carbon dioxide would fall by more than 20 per cent, and premature deaths from air pollution would be reduced by more than 50 per cent.

Governments and international organisations have responded to criticism of the large fiscal cost of some renewable energy policies (OECD 2015). Feed-in tariffs to renewable energy producers have stimulated increased supply in many countries, but consumers in Germany noticed increased electricity prices, governments noted their ballooning fiscal cost, and there was diminishing need for support as production costs fell when solar PV and wind generation technologies improved. Competitive tender systems have replaced FIT in some countries, and others have changed to feed-in premiums. The European Commission State Aid guidelines instructed EU countries in 2014 to begin using tendering systems and all new renewable energy systems to use tenders by 2017 (REN21 2015). More than 20 countries have introduced green certificate trading systems for renewable energy. About thirty countries have reduced various tax rates to encourage renewable energy supply. A total of 23 countries, including the USA, have set up investment or production tax credits. Governments can adjust trading schemes and tax incentive schemes as take-up rates increase, technology change increases renewable energy competitiveness, and the schemes' impacts on government budgets become more apparent.

The merit of each of the arguments for favouring renewable energy in energy policy is in part an empirical matter and has to be considered on a case-by-case basis within each country, taking into account whether it has plentiful renewable energy power sources, its residents suffer health impacts because of emissions from domestic coal power stations, it has a realistic chance of achieving renewable energy technological leadership, and other pertinent matters. In each case, where it is judged there is a valid case in principle for policy to favour renewable energy, additional questions must be asked about policy target accuracy, effectiveness of policy, duration that policy needs to be maintained and the expected costs of policy. Only then can a judgment be made on the merit of renewable energy-favouring policies. The nation's location, resource endowments, trade and energy contexts are often important when developing energy policies, and they are discussed next. Section 6 proposes some fundamental tests nations can apply when developing renewable energy policy.

5 Context

Context is important for countries considering introducing renewable energy policies. Forty-seven countries are island nations (26 per cent of all nations), which are often self-reliant for electricity generation. Countries with contiguous or close neighbours can link electricity transmission systems, allowing easier matching of demand and supply across shared generation and transmission systems.

Countries differ in their endowments of renewable (and nonrenewable) energy resources. The location of those resources also matters; are they sited close to, or distant from locations where most energy is needed? Electricity can be transmitted by cable, but there are energy losses, which averaged 6.5 per cent in the USA for 2007 (US Energy Information Administration 2009). High-voltage direct current (HVDC) systems are used to transmit electricity long distances, and undersea, as occurs between South and North Islands of New Zealand, Tasmania and mainland Australia, Great Britain and continental Europe. Submarine cables are at present up to 600 km in length. HVDC transmission has lower energy loss than alternating current (AC) transmission, but there is additional cost in switching between HVDC and AC.

The distribution of fossil fuel endowments, and of nuclear fuels, is highly skewed across countries and often, also, within countries. Countries lacking domestic fossil fuels or the elements needed for nuclear power plants have to import them to enable electricity generation from those energy carriers. Countries differ in the availability of conveniently located biofuel feedstock and may need to import such fuels to enable biofuel production. Some electricity generation facilities, such as nuclear power plants, have high output of base load electricity. Their characteristics make them unsuitable for small economies or for easy integration as intermittent providers of electricity. Individual wind power, solar power and wave power generators are intermittent providers of electricity and are not dispatchable. Supply of some biofuels may be seasonal, necessitating storage or complementing by other feedstock to enable consistent power availability.

Nations setting renewable energy goals and introducing policies supporting renewable electricity must consider electricity demand forecasts and the infrastructure currently available to generate and transmit electricity. Investment will be needed where demand for electricity is growing, and there is little excess capacity in generation and transmission infrastructure and renewable energy investment can help meet the demand for additional electricity. Where demand is static and infrastructure adequate, there is much less need or opportunity to invest in new generating capacity including renewable energy. If some infrastructure is obsolete or at the end of its life, investment will be needed even if demand for electricity is static, and investment in renewable energy can help meet the impending need for electricity generation. If a country has renewable energy projects to meet foreseeable demand already approved for construction, as in New Zealand, there is reduced merit in policies to promote further renewable energy generation.

Renewable electricity can substitute for electricity generated using fossil fuels (coal, gas, diesel) and for fossil fuels directly (e.g. electric-powered vehicles providing a similar service to petrol- or diesel-powered vehicles). Decision-makers can consider fuel costs as well as capital costs when deciding which technology to use in transport, industry or in homes. Some renewable energy technologies such as solar PV experienced significant capital cost reductions during the last decade, as technological advances were achieved, scale of production increased and installation expertise grew. For example, total installed costs of utility-scale PV systems fell by between 29 per cent and 65 per cent between 2010 and 2014 depending on the region (IRENA 2015).

Capital-intensive energy-using technologies are often long-lived, and fuel prices change, sometimes very dramatically, as occurred during 2014–2015 when Brent Crude oil price fell by 65 per cent. Gas price in North America fell by 39 per cent between October 2008 and October 2014 as hydraulic fracking and horizontal drilling brought greatly increased supply to that market (EIA 2014). Countries contemplating introducing policies such as feed-in tariffs (FIT) to promote renewable energy need to consider: how renewable energy capital costs may change over time; whether 'oversubscription' and 'lock-in' could occur with budget impacts; and how prices for energy carriers such as oil or gas may change over time. Falling oil and gas prices can rapidly undermine the effectiveness of FIT in promoting the use of renewable energy. Alternatively, countries using subsidies that ensure grid parity between renewable sourced electricity and fossil fuel-generated electricity will experience growing fiscal costs if fossil fuel prices fall significantly.

The structure of the energy sector within countries is shaped by legislation and regulation. Some countries have a clear separation between generation, transmission and retail sectors. In other countries, vertically integrated firms are both electricity generators and retailers. Policy development has to be cognizant of the structure of the energy sector within a country. Nations need to determine which of these many factors are pertinent when making decisions on renewable energy policies.

Systems thinking is essential when considering energy policy as piecemeal actions may lead to outcomes contrary to goals sought when introducing new policies (Helm 2014). Germany introduced a set of policies (*Energiewende*) in 2010 that promoted renewable energy with the intent of reducing use of fossil fuels and CO_2 emissions. The outcomes have been startling: coal consumption has soared in Germany; GHG emissions increased; at times electricity has a negative price; traditional energy firm business models have been undermined with enormous loss of energy company value. Before introducing renewable energy policies, modelling is needed of the policies' impacts upon critical measures such as national and global CO_2 emissions, national energy security, fiscal and economic cost.

6 Principles for renewable energy policy design

Responding to climate change is an enormous challenge. The OECD (2013a, b) observes that it is unlikely the challenge can be met unless countries apply policy instruments that are as cost-effective as possible. Nations first need to consider their energy, economic, geographic and other contexts before developing or modifying policies supporting (or opposing) renewable energy. Asking some fundamental questions may reduce the likelihood of introducing unnecessary, ineffective or harmful renewable energy policies. A structured approach to policy making is proposed.

As outlined in Sections 2 and 3, eight static reasons and one dynamic reason are frequently cited in high-income countries for introducing renewable energy policies. Nations that judge that any or all of those nine situations are relevant to them may wish to introduce measures to address the energy supply or use issue, and ultimately to further the nation's high-level goals. Six policy design principles are proposed to aid policy choices.

1. Use direct rather than indirect approaches to tackle the energy issue.
2. Use policies that are effective at addressing the energy issue.
3. Use policies that are cost-effective at addressing the energy issue.
4. Use policies whose energy system effects are known and understood.
5. Use policies whose economy-wide effects are known and understood.
6. Use policies that are administratively feasible, difficult to evade, and have acceptable compliance costs.

Use of those design principles will steer countries towards effective, low-cost, no-surprise policies, and away from indirect, ineffective, high-cost, spillover-undermined policies. Direct policies such as carbon prices and removal of energy subsidies will incentivise multiple beneficial responses. Indirect policies such as subsidies for renewable energy generation are likely to stimulate fewer responses and may even be counter-productive if they lead to carbon leakage across national borders (Edenhofer *et al*. 2013; van der Ploeg and Withagen 2013).

Decision support systems have been developed for many resource and environmental issues including biodiversity reserve selection (Hajkowicz *et al*. 2007), fisheries policy selection (Cullen *et al*. 2000) and environmental resource allocation (Strategic Policy Group 1995). Common features of decision support approaches include identification of a problem requiring a decision, identification of possible options, selection of an option, implementation of the preferred option. Arguably, choice of policy to achieve an energy-related goal can be tackled using a decision support approach.

Figure 2 illustrates a series of tests that renewable energy policies could be subjected to before introduction. After subjecting renewable energy policies to those tests, decision-makers can judge whether there is a sufficiently good case to introduce a new policy. If a proposed renewable energy policy is not first best, there needs to be a compelling case that energy market distortions and external costs have been reduced as much as is currently achievable. If those tests are both met, then serious effort can be applied to cost-effectiveness analysis, energy system simulation and other scrutiny of second best policies so that decision-makers are well informed about the implications of policy choices (Holttinen *et al*. 2015; Mason *et al*. 2013). Many countries have chosen to use 'renewable energy policies' that are indirect, high-cost ways to tackle energy issues when direct, lower-cost options were available. Recent use of reverse auctions to set FIT prices for renewable energy has shown they can provide investor certainty and avoid misalignment of FIT rate with generation costs and hence avoid low take-up and over-subsidisation that occurred with early FIT schemes (Buckman *et al*. 2014).

7 Conclusion

Renewable energy has become an increasingly important contributor to energy supply and consumption in many countries. Rapid, and steady, technological improvement in solar PV and wind power generation, respectively, has lowered their capital and production costs and increased their competitiveness, offsetting the recent sharp fall in fossil fuel prices. Decarbonisation of energy consumed in economies is essential to reduce CO_2 emissions and to slow the rate of climate change. There are many barriers to increased consumption of renewable energy, particularly subsidies to fossil fuels and failure to account for the external costs they impose. Directly tackling those matters will significantly improve the prospects for increased use of renewable energy.

There are additional static, and in some cases dynamic, reasons for energy policy to favour renewable energy. But policies need to be carefully screened to ensure they use direct, low-cost measures that are cost-effective and time-limited. Several countries have completed energy policy reform and reduced fossil fuel subsidies, but few countries including Australia and New Zealand have priced carbon at levels that internalise the marginal costs of fossil fuel consumption. Renewable energy policy evolution is also occurring as

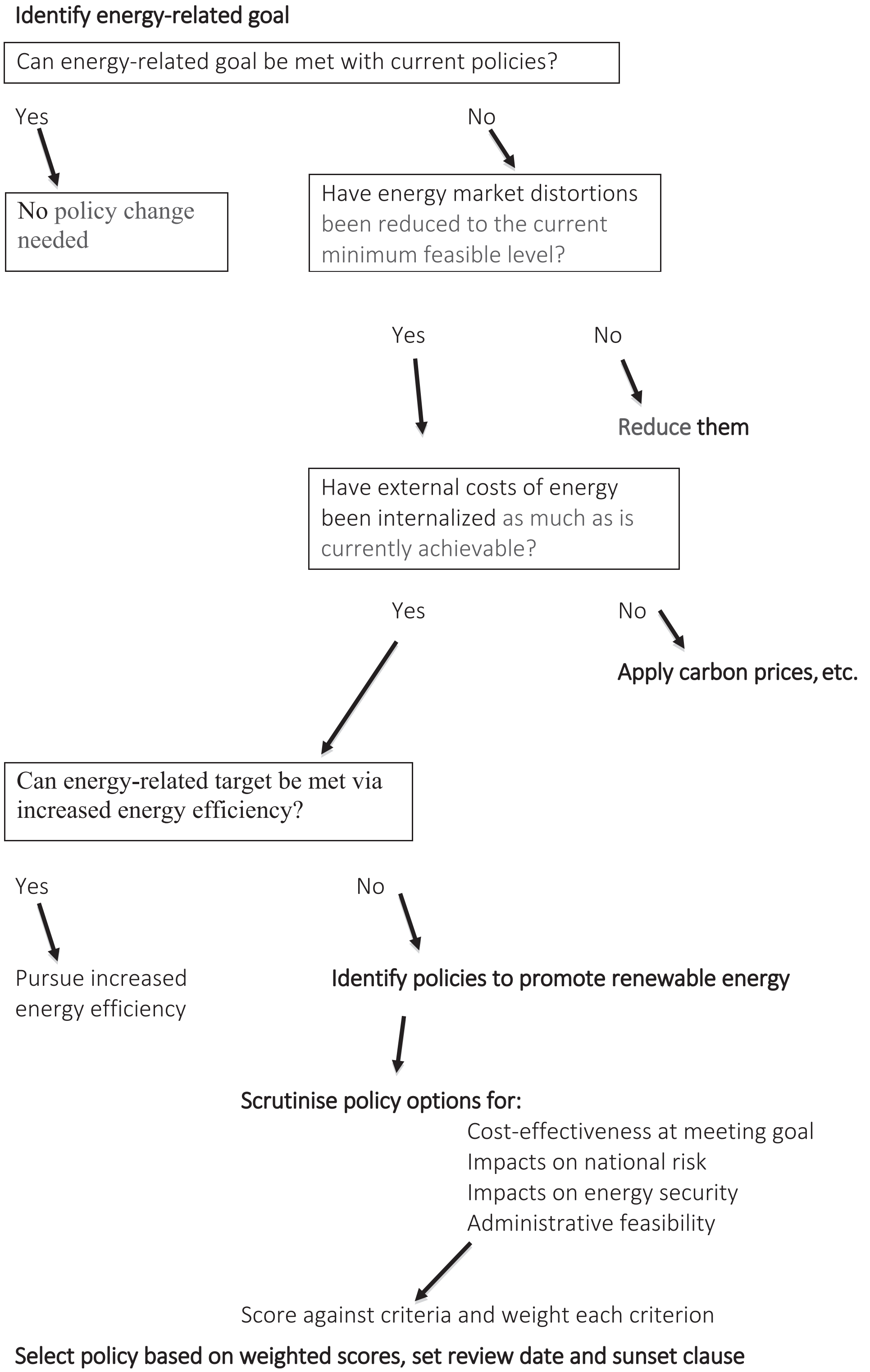

Figure 2 A decision support framework for potential renewable energy policies.

governments act to reduce economic rents to generators and use competitive mechanisms such as reverse auctions to incentivise increased renewable energy supplies.

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