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Stephany Griffith-Jones
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Abstract

This paper examines if recent sharp declines in the price of oil and other fossil fuels will discourage private investment in renewable energy, which is key for climate change mitigation.

The increase in private renewables investment in the Latin America and the Caribbean (LAC) region have been driven by sharp declines in costs alongside supportive policies.

The sharp fall in the price of oil and other fossil fuels since 2014 risks disrupting continued private investment in renewables if they becomes insufficiently profitable.

The decline in oil and other fossil fuel prices presents an opportunity for governments to reduce subsidies to them. For countries without such large subsidies, governments could increase taxes on them. This would alleviate their negative effects on climate change. However, it may require carefully designed fiscal measures to compensate low-income consumers. Where profitability of renewables was damaged by the fall in cost of fossil fuels, some of the resources could be used both for temporary subsidies on renewables as well as funding research on reducing their costs.

Public development banks can play a valuable role supporting technological innovation for renewables and providing cheaper finance for them.

Policies of taxes and subsidies on fossil fuel production need to be counter-cyclical and linked to the level of oil or natural gas price. Thus when the price of the particular fossil fuel fell - which is the main competitor of renewables in the country - taxes on them could rise, and/or subsidies on them could be lowered. The resources could be used to subsidize renewables, and/or for research in them, as well as compensate poor consumers hurt by those measures. When the price of the fossil fuel rises, taxes on them could be lowered. A very attractive feature of this counter-cyclical mechanism is that it would fund itself, not requiring additional fiscal expenditure.

Introduction

Mitigating climate change requires a large shift of electricity production from fossil fuels to renewable energy. This applies for all countries and regions. If the future is powered to a far greater extent by renewable energy, in part to reduce greenhouse gas (GHG) emissions, it makes sense to transition sooner rather than having to make costly shifts at a later stage.

The question is how to encourage renewable energy projects at scale, in the context of volatile fossil fuel prices, particularly when fossil fuel alternatives may become cheaper at current market prices.

Given the scale of the investment required, it is clear that a large proportion of investment in renewables will need to come from the private sector. However, private investors are often not motivated by environmental concerns, but by the relative risk-adjusted returns available from different potential investments. A key factor to assure significant levels of private investment is whether renewable energy investments are competitive with alternative investments. If not, a key question, which must be asked is how can this situation be changed?

The international community has increasingly understood that there are huge environmental negative externalities linked to anthropogenic greenhouse gas emissions, including their impacts on climate change. Governments have supported private investment in renewable energy to reduce emissions through a number of measures, such as Feed-in Tariffs, other subsidies and auctions. These measures implicitly allocate a higher price for carbon (the main greenhouse gas emission) than the market price to take account of environmental externalities, though fixing a higher carbon price, if politically feasible, would be a better solution. However, the cost of many renewable technologies has reduced drastically over the last few years, which has allowed some reduction of subsidies whilst investment in renewables has continued to expand.

Recent sharp movements in oil and other fossil fuel prices (including gas and coal), and particularly the sharp fall in the price of oil and other fossil fuel prices since 2014, remind us that very large price shifts are possible. This raises the issues of commercial returns for renewables and that of volatile fossil fuel prices. If the profitability of investment in renewables is lowered, and if there is increasing uncertainty about such profitability in the future, this could discourage investment in renewables. This seems to require additional and complementary policy tools to the ones mentioned above to deal with the issue of volatility of fossil fuel prices.

Some counter-cyclical tools may need to be incorporated into energy policies, linked to the price of fossil fuels. Thus when the price of oil or other fossil fuels fall significantly, it may be desirable to cut subsidies and/or raise taxes on such fossil fuels and use those revenues to subsidize renewables - for example through Feed-in Tariffs or other mechanisms - as well as funding research to lower their cost and increase their reliability. When the price of fossil fuels, and especially oil, goes up significantly, taxes on fossil fuels could be reduced, as would subsidies to renewables, as renewables would become again commercially competitive without or with less support. It would be best to apply such counter-cyclical measures to fluctuations in prices of the fossil fuel(s) which is/are most important in the particular country. Rules could be defined ex-ante, to increase predictability, but adjusted to the scale of fluctuation to prices of oil, or other fossil fuels, as well as to other major changes, such as evolving cost of renewables. A key positive aspect of such a mechanism is that it would be fully funded in that any additional costs borne by governments in one sector, for example in renewables, would be financed by the other sectors, such as oil and other fossil fuels.

To date the impact of large price shifts of oil as well as other fossil fuels, on the commercial incentives to invest in renewable energy have not been sufficiently explored, nor their possible implications for policy. This is surprising as the relative price of renewables vis-à-vis fossil fuels is perhaps one of the most important factors influencing private investors. Only a few analysts have focused on this important issue; for example, the Global Commission on Economy and Climate (GCEC, 2014) has analyzed the issue and concluded that if lower fossil fuel prices were to persist, this would drive renewable energy sources further away from "parity" with fossil fuel options, and private investors may then choose to give renewables a smaller role in their future energy choices. However, some supporters of renewable energy seem to merely project continued expansion of renewables, without taking account of the changes in relative prices, as well as the likely need for a policy response to maintain the right incentives for increased investment in renewables.

As this is a relatively new area of work, this paper first explores how fossil fuels prices could affect renewable energy investment decisions under a range of price scenarios, given their impact on the relative risk-adjusted returns of renewables. As country context is all-important in this area, we particularly apply this question to Latin America and Caribbean countries, where oil and other fossil fuels represent a significantly higher proportion of the production of electricity. We then expand on this with the case study of Chile, looking especially at renewable energy powering large copper mines in the north of Chile.

We look at how different oil and fossil fuel price scenarios (current and expected future prices), would affect the relative attractiveness of different renewable energy options, and measures by policy-makers, to encourage investment in renewables. This includes the potential role of development banks and the mechanisms they could use to fund renewable energy to provide sufficient length of maturity of loans as well as to reduce costs. We also briefly touch on other policy areas that are important, such as ensuring sufficient capacity in grids, as well as institutional aspects, such as the role of energy co-operatives. More broadly we evaluate the possibility of using counter-cyclical mechanisms, for example via subsidies and/or taxes on fossil fuels and possible subsidies to renewables to vary with the price of fossil fuels, so as to ensure the profitability of renewables in ways that can be fully funded.

Section I sets the scene for our analysis. It outlines trends in production in renewables as well as their projections. It then examines the past evolution of costs of different renewables and the likely future trends of such costs. Next it refers to the scale of fossil fuel subsidies worldwide. We then examine the structure of energy supplies in different Latin American and Caribbean countries to reflect their diversity, and categorize those countries according to their main features of supply structure. We then briefly examine the different Latin American and Caribbean public schemes available for encouraging investment in renewables.

Section II examines the impact of different future levels of oil and other fossil fuel prices and the effect that would have on future private investment in renewables. This is examined under three scenarios: a) current oil and fossil fuel prices or slightly higher, b) lower prices than currently experienced and c) a return of significantly higher prices. It does so in a broader context of different conditions and risks that influence private investment

Section III presents the case study on Chile, with an emphasis on solar energy where Chile has a clear comparative advantage in the north of the country.

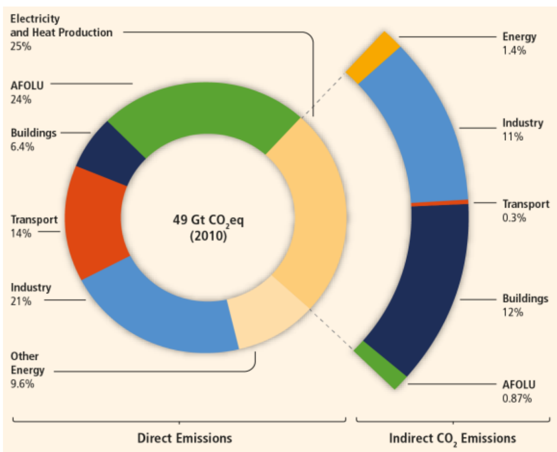
Section IV concludes with a summary, policy recommendations and suggestions for future research.

I. Key economic background

A. Renewable production increase impressive

Transitioning energy production is extremely important to mitigate climate change, as according to the Intergovernmental Panel on Climate Change it accounted for around twenty five percent of global greenhouse emissions (GHG) in 2010.

Figure 1
Greenhouse gas emissions by economic sectors[a]



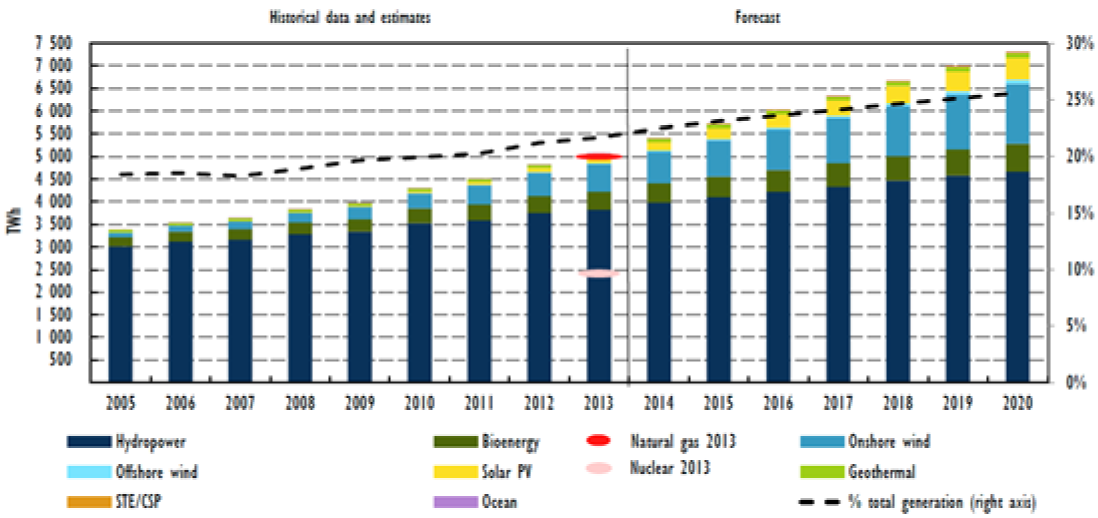
Source: IPCC 2014: 8

[a] Total anthropogenic GHG emissions (GtCO2eq / yr) by economic sectors. Inner circle shows direct GHG emission shares (in % of total anthropogenic GHG emissions) of five economic sectors in 2010. Pull-out shows how indirect CO2 emission shares (in % of total anthropogenic GHG emissions) from electricity and heat production are attributed to sectors of final energy use. 'Other Energy' refers to all GHG emission sources in the energy sector as defined in Annex II other than electricity and heat production [A.II.9.1]. The emissions data from Agriculture, Forestry and Other Land Use (AFOLU) includes land-based CO2 emissions from forest fires, peat fires and peat decay that approximate to net CO2 flux from the Forestry and Other Land Use (FOLU) sub-sector as described in Chapter 11 of the report. Emissions are converted into CO2-equivalents based on GWP100 6 from the IPCC Second Assessment Report. Sector definitions are provided in Annex II.9.

To reach targets consistent with a maximum increase of 2 degrees C (Carbon Brief 2014), or even below that (Shaw 2013), it is urgent to limit the increases in GHG arising from energy. For this reason, renewable energy needs to be expanded, in part through substituting fossil fuel energy production, as well as to provide access to electricity to those that still do not have, nor have enough.

As we can see in figure 2 below, worldwide renewable energy production (broadly defined to include hydroelectric power) has increased significantly in recent years, both in absolute terms and as a percentage of total energy production, growing to 20 percent of total energy production by 2013. The key concern expressed in this paper is whether such a rising trend can be maintained if fossil fuel prices were to remain significantly lower.

Figure 2
Global renewable electricity production, historical and projected

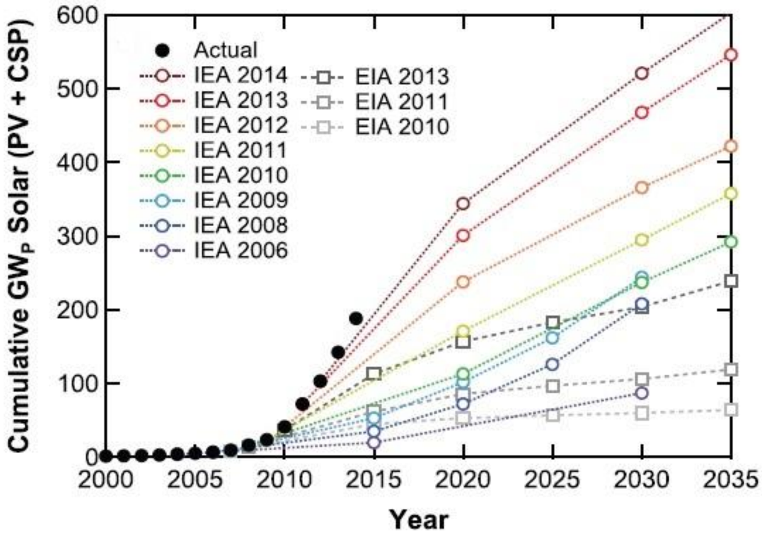


Source: Waldron 2015: 6.

As Schmalensee, R. et al. (2015) show in some detail, expansion of renewables has till the time of writing often surpassed expectations. The real world expansion of solar energy has been far larger than the Energy Information Administration's (EIA) and the International Energy Agency's (IEA) projections in their energy outlook reports. As can be seen in figure 3, the growth of solar power –photovoltaic (PV) and concentrated solar power (CSP)– has consistently outstripped their projections. The 2006 IEA projection for cumulative solar capacity in 2030 was surpassed in 2012 and the 2011 EIA projection for 2025 was surpassed in 2014.

Latin America has led the way in some aspects of renewables expansion. For example, from 2002 to 2012 electricity generated by wind increased on average by 26 percent worldwide. In South America, during that same period, it increased 51 percent, and in Central America 42 percent, according to Tabare Arroyo, a WWF energy specialist based in Mexico (Abiven 2015). In December 2014, the WWF declared Latin America the leading region in the world on renewable energy, naming five top performers, with Costa Rica being on its way to becoming "the first Latin American country with 100 percent renewable electricity", as well as Brazil, Chile, Mexico and Uruguay being on the list (Abiven 2015). It should be noted that 100% renewable electricity could be obtained only if hydro-electricity is included, as renewables such as wind and solar do not currently provide continuous supply at large enough scale (low cost battery storage and grid upgrades ccould change this picture).

Figure 3
Solar capacity growth compared to projections[a]



Source: Schmalensee, R. et al. 2015: 127.
[a] International Energy Agency (IEA) and Energy Information Administration (EIA) projections for cumulative PV and CSP installed capacity are represented by empty coloured circles and squares; actual historical data for cumulative PV and CSP installed capacity are represented by filled black circles. Dotted lines are given as guides to the eye. Projections are from the IEA *World Energy Outlook* reports over the period from 2006 to 2014 and the EIA *Annual Energy Outlook* reports over the period from 2010 to 2013; actual data for cumulative PV capacity are from EPIA4 and IHS, Inc.; actual data for cumulative CSP capacity are from REN21.

Many project a strong continued investment and the increased production of renewable electricity, both globally and in Latin America. For example Waldron (2015) projects renewable electricity to increase globally by 45% from 2013 to 2020. The MIT study by Schmalensee, R. et al. (op cit.) also projects continued and large expansion of different renewables. Similarly, other sources (e.g. Flavin et al. 2014) argue that renewables have entered mainstream energy markets and have become economically competitive, sometimes by wide margins in relation to fossil fuels. Whilst this was true when the price of oil and natural gas were high, it is far less evident ─particularly in certain countries and contexts─ when the price of oil (and other fossil fuels) is so much lower. This is especially the case if these prices were to remain so low as time of writing, unless policy measures are taken to compensate this where appropriate.

B. Costs of renewable energy

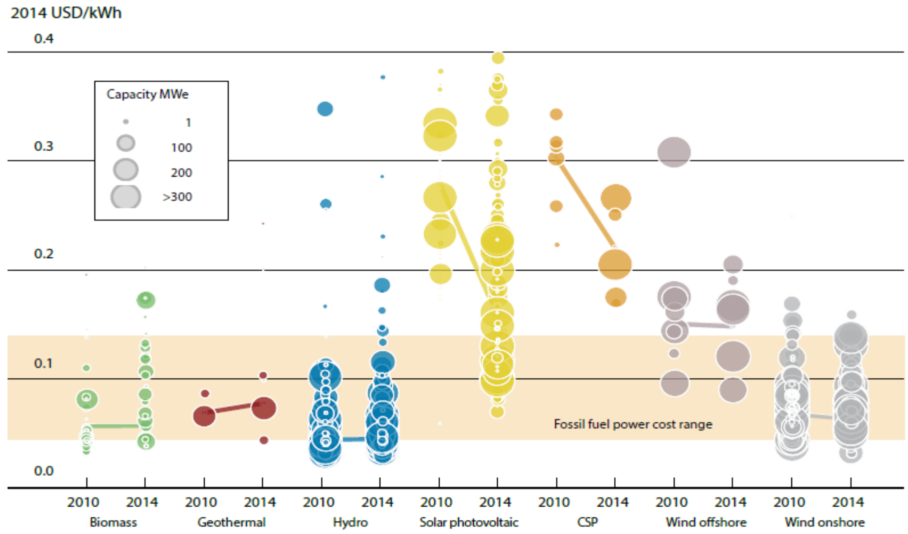
A major reason for the increase in investment in renewables in recent years has been the significant reduction in their costs. As can be seen in Figure 4, according to IRENA (2015), an institution specialized in detailed and in-depth evaluation of costs of renewables, the cost competiveness of renewable power generation technologies had significantly improved by 2014, due to significant reductions of the cost of renewables, compared to fossil fuel power generation. However, it is important to note that the recent fall in the price of oil and other fossil fuels since 2014, as well as recent reductions in renewable power generation costs, are not fully reflected in the latest graphs by IRENA.[1]

As figure 4 and others below show, the cost-competitiveness of renewable energy generation technologies had reached historically low levels. Biomass, hydropower, geothermal and onshore wind can all now provide electricity competitively compared to fossil fuel-fired power generation at previous levels. Most impressively, as figure 4 shows, the levelised cost of electricity (LCOE) of solar

[1] According to interviews with IRENA experts in Bonn with one of the authors.

photovoltaics (PV) has halved between 2010 and 2014, so that solar PV became increasingly competitive at the utility scale.

Figure 4
The levelized cost of electricity from utility-scale renewable technologies, 2010 and 2014 [a]



Source: IRENA 2015: 27.
[a] Size of the diameter of the circle represents the size of the project. The centre of each circle is the value for the cost of each project on the Y axis. Real weighted average cost of capital is 7.5% in OECD countries and China; 10% in the rest of the world.

The levelized cost of electricity (LCOE) of a power generation technology reflects several factors: resource quality, equipment cost and performance, the balance of project costs, fuel costs (if any), operation and maintenance costs, the economic lifespan of the project, and the cost of capital.

Most estimates of costs, however, assume the same cost of capital for all renewable facilities across countries. This can be somewhat misleading as the cost of finance can be much higher in emerging and developing countries, so that actual LCOE of many types of renewables is often much higher than the headline figure, as the cost of renewables is far more front-loaded than for fossil fuel generation. This problem is amplified by the fact that financing can be a larger component of total project costs for renewables than fossil fuels, so that a higher cost of finance in a developing country context has a larger negative effect on a renewables than a fossil fuel project (Pueyo et al. 2015).

However, we can see there is a continual decline in the cost of electricity from renewable-based technologies, due to falling renewable power generation equipment costs, increasingly efficient technologies as well as other factors.

Installed costs for onshore wind power, solar PV and CSP have continued to fall, while their performance has simultaneously improved. Particularly impressive has been the decline of solar PV module prices, which in 2014, according to IRENA (op cit.), were around 75% lower than their levels at the end of 2009. Other sources also report similar dramatic reductions in the cost of solar PV module prices (for a review of different sources for estimates of costs, see Pueyo et al., op cit). It should, however, be borne in mind that the total costs of solar panels may be the minority portion of total costs of energy produced by them.[2] Between 2010 and 2014 the total installed costs of utility-scale PV systems have fallen by 29% to 65%, depending on the region. The LCOE of utility-scale solar PV has fallen by half in four years. The most competitive utility scale solar PV projects are now regularly

[2] According to interviews, PV panel costs remain approximately half of total construction costs for utility-scale generation – so are not a small part of overall costs of energy. From a lifetime cost perspective, construction costs typically comprise 90% of capital costs and annual operating costs generally in the range 1-2% of capital costs. Construction costs therefore dominate lifetime generation costs after discounting.

delivering electricity for just USD 0.06 per kilowatt-hour (kWh) without financial support, compared to a range of USD 0.045 to 0.14 per kWh for fossil fuel power plants. Examples of USD 0.06 per kilowatt-hour solar tariffs are now seen in Chile, Africa, China, India and the Middle East, as of late 2016.

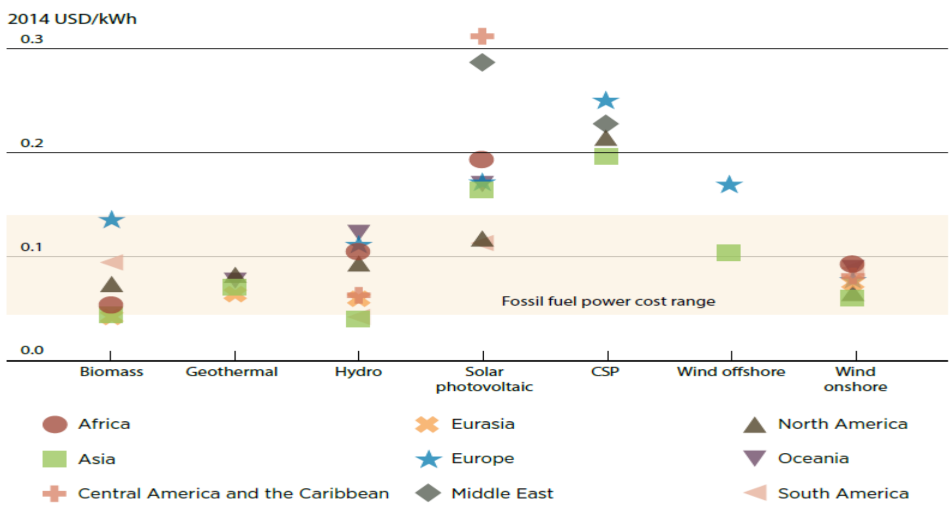
Even lower costs for utility-scale solar PV, down to USD 0.03/kWh, are possible where excellent resources and low-cost finance are available.[3] However, as pointed out above, a problem in emerging and developing countries with abundant renewable resources can often be the cost of finance, which is not fully reflected in these estimates. This increases the disadvantages of renewables vis-à-vis fossil fuels, as financing costs can be a larger proportion of total project costs with renewables.

Onshore wind can now be one of the most competitive sources of electricity available and its costs continue to decline, albeit more slowly than for solar PV (see Figures 4 and 5). Technology improvements alongside installation cost reductions now mean that the LCOE of onshore wind was within the same cost range, or even lower, than for fossil fuels, especially before recent oil price reductions. The best wind projects around the world are consistently delivering electricity for USD 0.05/kWh without financial support, as of 2014 (see IRENA, op cit.).

LCOEs of the more mature renewable power generation technologies –biomass, geothermal and hydropower– have been broadly stable since 2010. However, where under-utilized, these mature technologies could provide some of the cheapest electricity of any source.

Regional, weighted average costs of electricity from biomass, geothermal, hydropower and onshore wind were in the range, or even span a lower range, than estimated fossil fuel-fired electricity generation costs. Because of LCOE reductions, solar PV costs also increasingly fell within that range. Given current installation costs and the performance of today's renewable technologies, as well as the costs of conventional technologies, renewable energy generation is increasingly competing with fossil fuels, according to IRENA, without financial support (figure 5, below).

Figure 5
Weighted average cost of electricity by region for utility scale renewable technologies, compared with fossil fuel power generation costs, 2013/2014



Source: IRENA 2015:14.
[a] Real weighted average cost of capital of 7.5% in OECD countries and China; 10% in the rest of the world.

[3] The reverse auctions for the Al Maktoum phases 2 and 3 plants in Dubai and the Sweihan plant in Abu Dhabi came in around USD 0.03 per kilowatt-hour (kWh) in 2016. These are well-publicisied but unusual cases because the land and AC electrical system was provided by the government, there are exceptional solar resources, low-cost capital was provided and because of huge economies of scale (plants of up to 1,000 MW).

According to IRENA (op cit.), the weighted average LCOE of utility-scale solar PV in China and North America (the world's two largest power-consuming markets overall) and in South America, had also fallen into the range of fossil fuel-fired electricity costs. For utility-scale solar PV projects installed in 2013 and 2014, the weighted average LCOE by region ranged from a low of around USD 0.11 to USD 0.12/kWh in South and North America respectively to over USD 0.31/kWh in Central America and the Caribbean. However for individual projects, the range of costs is much wider. In various countries with good solar resources, projects are now being built with an LCOE of USD 0.06/kWh without public financial support, while recent tenders in Abu Dhabi and Dubai, in the United Arab Emirates, resulted in successful bids for a solar PV power purchase agreement (PPA) for just USD 0.03/kWh. See also table 1, which provides the LCOE for renewables compared to fossil fuels, focussing just on Latin America.

Where good resources exist and low-cost financing is available, utility-scale solar PV projects that are now being built (for example in Dubai, Chile and other parts of the world) were estimated to provide electricity at a lower cost than fossil fuels, without any financial support, before the decline of fossil fuel prices.

The story of the reduced cost and growing competiveness of renewables remains very much a nuanced one, even before the recent fall in fossil fuel prices. This is because renewable energy generation LCOEs costs have a wide range due to site and country specific factors, such as resource availability, availability of supporting infrastructure, grid connection costs, cost of finance and labour. What matters in the end are comparative costs and risk adjusted returns on investments in specific locations, which vary tremendously.

To summarize, regional, weighted average costs of electricity from biomass, geothermal, hydropower and onshore wind were in the range, or even a lower range, than estimated fossil fuel-fired electricity generation costs. Thanks to LCOE reductions, solar PV costs also increasingly fell within that range. Given the installation costs and the performance of today's renewable technologies, and the costs of conventional technologies, renewable power generation was increasingly competing head-to-head with fossil fuels, without financial support. However, as pointed out above, the key is the comparative cost and risk adjusted return of renewables and fossil fuels in particular locations. Furthermore, the fall in the price of fossil fuels, especially if prices continue at their present level or similar, can alter this trend.

As reflected in figure 5, there are still **wide price disparities not just among renewable energy technologies, but also between different countries and regions.** For example, according to the IRENA research, South America and North America had the lowest costs in Solar PV, and was competitive with fossil fuel power. Central America and the Caribbean were amongst those having the lowest costs for wind offshore. The differences reflected amongst regions sometimes relate to resource availability, but also reflect market conditions, for example for financing, balance-of-system costs and regulations. Table 1, based on an IADB report, provides the LCOE for renewables compared to fossil fuels, focussing just on Latin America. Again, these do not fully reflect the decline in the price of fossil fuels since 2014.

Another key issue is the impact of expanding renewables at the system level. This is particularly important where the renewable technology in question is 'intermittent', meaning that it cannot be turned on or off at will, but is dependent on whether the wind is blowing or the sun is shining. There are currently[4] technical limits to what proportion of a total energy mix can be constituted in this way, which can create major barriers to capacity expansion, and need to be factored in when comparing headline LCOE estimates.

[4] Low cost battery storage and grid upgrades could change this picture. Lithium ion battery systems are seeing a similar cost reduction profile to PV modules at around 12% compound annual cost reductions.

Table 1
Cost ranges for renewables and fossil fuels in Latin America, as of 2014

		Levelized Cost of Electricity (LCOE)
Biomass	Utility-scale	0.04-0.20
	Industrial co-generation or self-generation	Gasification: 0.06-0.24 Anaerobic digestion: (biogas) 0.06-0.19 (landfill gas) 0.04-0.07
	Off-grid	0.06-0.24
Geothermal	Utility-scale	0.05-0.14
Hydropower	Utility-scale	Large hydro: 0.02-0.12 Small hydro: 0.03-0.23
	Off-grid	0.05-0.40
Solar PV	Distributed (rooftop)	0.16-0.55
	Utility-scale	0.09-0.40
	Off-grid	0.20-0.45
Concentrating solar power (CSP)	Utility-scale	0.12-0.38
Marine	Utility-scale	0.21-0.28
Wind	Utility-scale onshore	0.04-0.16
	Utility-scale offshore	0.15-0.23
	Off-grid	0.15-0.20
Fossil fuels		0.04-0.13

Source: (IADB, 2014: 10).

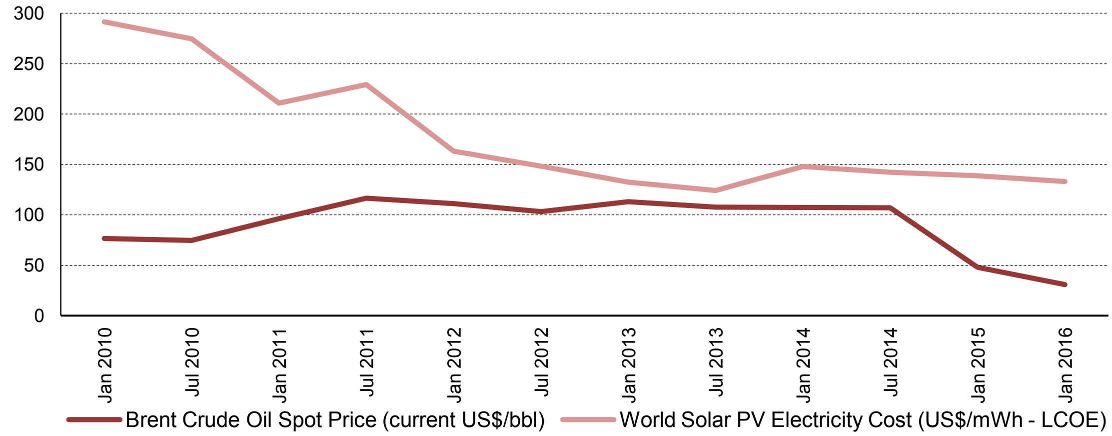
C. Fluctuating oil prices and their linkages with natural gas

Figure 6 shows the clear decline of the levelized cost (LCOE) of photovoltaic solar electricity generation in recent years, which has significantly increased the competitiveness of solar. Further cost reductions can still be expected in the future, which will further lower the weighted average LCOE (Fraunhofer ISE, 2015). Many potential future cost reductions will be driven by reduced balance-of-project costs, lower operation and maintenance as well as finance costs. Indeed, as we will discuss below, one of the areas of public policy can be to support reduction of the cost of finance, for example by greater use of public development banks.

Figure 6 also illustrates how much the price of oil has dropped during the latter part of 2014, in comparison with the cost of solar. Indeed, in 2016 there have been further falls in the price of oil (Brent $ per barrel), when it has hovered well below $50 per barrel. The fall in the price of oil has also been accompanied by a decline in the price of natural gas and of coal, which often competes more directly with renewables. In many Latin American countries, such as Mexico, Bolivia, and Argentina, natural gas is a significant contributor to electricity production; for the region as a whole, it contributes around 23% of total energy production. For Chile, coal is a very significant contributor to electricity production (see table 2, page 22).

The historical price observations for oil and gas set the context. Below, figure 7 shows two graphs charting the prices of Brent crude oil (a type of oil that provides a benchmark for world oil prices) and natural gas, respectively, between 2012 and 2015. They show how recently both oil and gas prices have fallen sharply in approximately the same period.

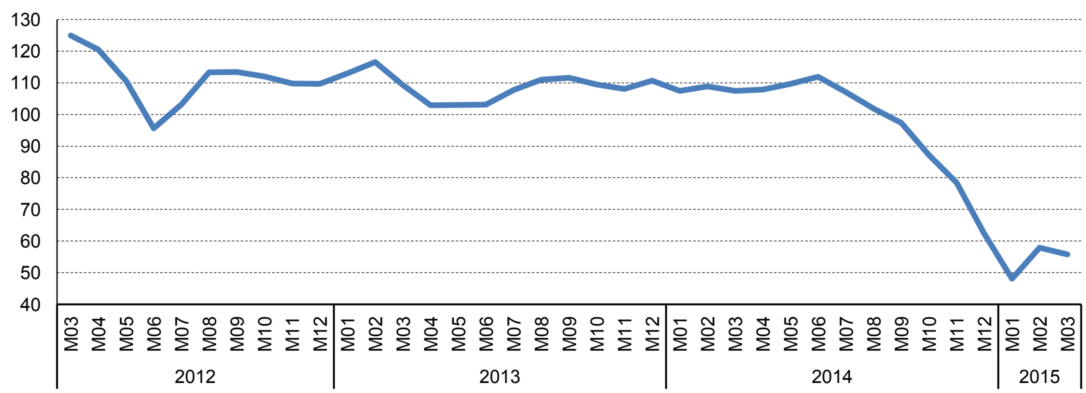
Figure 6
Energy prices — oil and solar[a]



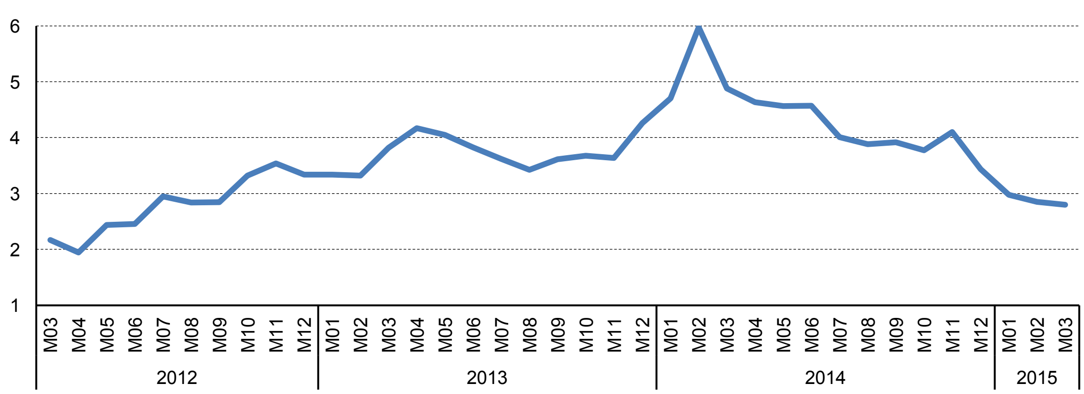
Sources: Bloomberg; Thomson Reuters Datastream.
[a] Levelised cost of thin-film photovoltaic electricity generation.

Figure 7
Brent crude oil and natural gas spot prices

A. Crude oil brent



B. Natural gas



Source: Seth 2015.

Indeed, the above graphs show that from November 2014 to March 2015, Brent crude oil and natural gas prices both fell dramatically. This seems to indicate a high level of dependency and similar price movement for the two commodities, at least in the recent period.

However, expanding the study period changes the picture somewhat. Between January 2013 and July 2014, Brent crude oil prices have remained stable in the range of $100-$115. Natural gas prices varied much more widely over the same period. Similarly, a clear uptrend is visible in the natural gas prices from March 2012 to December 2012 (around a 60 percent increase), while crude oil prices have dipped in the initial period and then remained stable.

From the above observations, there seems to be relatively little correlation between crude oil and natural gas prices, but a look at other data sources may offer a different view. The U.S. Energy Information Administration (EIA) provides historical data looking at the correlation between crude oil other energy products. Looking at this EIA data between Q1 of 2003 to Q3 of 2014, Seth (2015) found the average correlation between oil and gas prices was 26.53 percent.

However, it is important to note that the extent of this correlation has varied widely, influenced by factors such as which time period is selected, the extent of volatility in natural gas price changes, fluctuating global energy markets and policies, location in the world as well as many other factors (Hartley et al. 2008; Ramberg, D. et al 2010; EIA 2015).

There are good reasons, however, to think that this correlation may increase in the future, especially as both oil and natural gas are increasingly traded as financial assets. Also, when the price of oil falls, demand for natural gas is more likely to decline. Furthermore, the price of some contracts for natural gas are fixed, in terms of the price of oil, making the link more direct.

We have focused in this section, as well as in the previous one, on the relative costs of renewables and fossil fuel, as well as the varying price of fossil fuel inputs (in the case of renewables the cost of inputs tend to be zero, for example for solar or wind). However, other factors will also affect the decision to invest in renewables, as compared to fossil fuels for electricity, beyond the relative profitability. One of these other factors is risk; this relates for example to technological risk, if the technology is new. A second type of risk is whether the renewable energy (if it needs transporting to where it will be used) can be connected or not to the grid. This relates to the existence of enough grid capacity and the technical issues that need to be overcome for this purpose given, for example, the variability of the supply of renewables and the willingness of existing grid operators to allow the output of new renewables to be transported on their grid (interview material).

Therefore, the key variable we have defined for encouraging sufficient investment in renewables is getting a sufficient risk-related commercial return for them. Whether returns are considered ‘sufficient’ depends on how they compare with alternatives. In the energy sphere, the main ‘competitor’ for renewables is fossil fuels, which is the subject of the next section.

D. Subsidies for fossil fuels

One of the important determinants of fossil fuel versus renewables profitability are the massive subsidies allocated worldwide to fossil fuels. This is especially important under current conditions as such subsidies are even less justified with low fossil fuel prices. Indeed the current economic situation is perfect to reduce such subsidies for fossil fuels, and using some of those freed-up resources to ─ where necessary ─ increase subsidies for the production and installation of renewables and/or increase the spending on research to make renewables cheaper and more efficient. Cheaper renewables could in part compensate poor consumers who may be affected by the lower fossil fuel subsidies, and these consumers should also be benefiting from some pass-through from lower prices of oil to electricity. In this sense we broadly agree with the IMF when they stated: “Low international energy prices have opened a window of opportunity for countries to move towards more efficient pricing of energy” (IMF 2015a). Such cuts in fossil fuel subsidies should be linked to an overall policy framework of enabling more stable commercial returns for renewables, as proposed in this paper.

However, it is key to carry out a careful evaluation of the economic and social impact of large cuts in fossil fuel subsidies, and carefully design mechanisms that compensate in a reliable way and in advance, those poor consumers, who will suffer from any increase in prices of electricity resulting from cuts in fossil fuel subsidies; resources should be available from the cuts in subsidies to fossil fuel production of electricity to fund such compensation.

According to the Global Commission on Economy and Climate Report, total annual subsidies to fossil fuels in 2014 were estimated to be around US $600 billion (GCEC 2014: 9), of which most are provided by developing and emerging economies. Based on IEA estimates, around US $540 billion annually are provided by developing and emerging economies and $55-90 billion annually are provided by OECD member economies (GCEC 2014: 41).

However, the IMF (2015a) has estimated a far larger amount when it includes the negative externalities associated with the fossil fuel subsidies. Energy subsidies are projected, according to this IMF study, at US$5.3 trillion in 2015, or 6.5 percent of global GDP. Most of this arises from countries setting energy taxes below levels that fully reflect the environmental damage associated with energy consumption.

According to this latter IMF study, worldwide the countries that subsidize the most (as % of GDP or per capita) are those which are major producers and exporters of oil and natural gas.

As regards Latin America and the Caribbean (LAC), the scale of subsidies is smaller than in other regions, though still important. Indeed, the IMF (2015b) argues that in LAC high oil prices since the second half of the 2000s had increased pressures on countries to provide energy subsidies. Their negative implications for macroeconomic management, fiscal sustainability and the environment heightened policymakers' interest in this issue. As pointed out, the current low price environment for fossil fuels makes it important to cut fossil fuel subsidies now.

A dataset by the IMF (2015b) estimates that LAC subsidies amounted to about 1.8 per cent of GDP on average in 2011–13, with fuel subsidies representing about 1 per cent of GDP and those for electricity about 0.8 per cent of GDP. This measurement of subsidies is a lower level than given in other IMF reports (2015a), as it does not include forgone tax revenues or the cost of negative externalities. Inclusion of (broad brush) estimates of these costs would, according to IMF (2015a, 2015b) bring the LAC energy subsidy bill to around 3.8 per cent of GDP.

There is considerable variation in the size and types of energy subsidies across the LAC region. Fuel subsidies tend to be larger and more entrenched in oil-rich countries, where they are seen as a way of sharing resource wealth with the public. Given their importance in the production of energy, there will be more opposition to reducing them; however, the fact they are often an important part of those countries' government budgets, it may make it attractive for governments to cut, especially at a time of declining fiscal revenues linked to oil. In contrast to fuel subsidies, electricity subsidies are more common in low-income countries and particularly in Central America and in the Caribbean. In these countries, it may be more desirable to focus more on shifting any subsidies to renewables, when fossil fuel prices decline.

At a country level in the LAC region, one country ─Trinidad and Tobago─ is amongst the 10 largest subsidizers per capita in the world. The four largest subsidizers per capita in the LAC region, according to the IMF study (2015a), are Trinidad and Tobago, Venezuela, Ecuador and Argentina. However, no LAC country is amongst the 10 largest subsidizers in the world, if calculating it by looking at percentage of GDP. The four largest subsidizers as percentage of GDP used for subsidies in the region are similar to the above list: Venezuela, Trinidad and Tobago, Bolivia and Argentina. These are therefore the countries where there is both more space to cut subsidies, but there may be both more opposition from vested interests, and more need to compensate poor consumers, that may suffer from such subsidy cuts.

The IMF argues it is generally in countries' own interest to move ahead unilaterally with energy subsidy reform, though in practice issues like competitiveness, as well as other issues discussed above, need to be considered in the case of unilateral reduction. According to the IMF (2015b) top subsidizers stand to gain the most, as measured in terms of per cent of GDP and in per capita subsidies. The IMF (2015b) also claims benefits will mostly accrue at the local level, by reducing local pollution and generating much needed revenues. However, energy subsidy reform can, perhaps most importantly, also contribute to greenhouse gas emissions reductions and help countries make international climate pledges. Of course globally, the largest subsidizers in dollar terms are not from the LAC region, and those are the ones which need the most urgent reforms.

Along such lines, in October 2015, the IMF (IMF 2015c) urged and stressed that: “Lower oil prices provide a golden opportunity to reduce inefficient energy subsidies in favour of more productive and equitable spending. Energy tax reform could help reduce negative externalities caused by energy consumption, such as pollution and global warming”

E. The structure of energy production in Latin America and the Caribbean

A major determinant of the impact of fluctuations in oil prices (and other fossil fuels) on the renewables sector is the existing structure of energy production in different countries. This is linked to economic factors, for example the existing natural resources, productive capacity and the “lock-in” or path-dependency of major investments in technologies. It is also due to political economy factors as countries with large oil (or other fossil fuel) sectors have strong vested interests and lobbies in continuing down a fossil fuel powered path, and may be more likely to resist a policy framework which encourages renewables. Furthermore, countries with large oil sectors, both for exports and for local production, face important “lock-in” or path dependency issues that make it more difficult to change the structure of production towards renewables as easily and quickly as others. Countries without large fossil fuel sectors, and which have already embarked on important renewable programs, can often more easily maintain or expand frameworks favourable to renewables (Lütkenhorst et al.: 2014).

As a consequence, though the need to shift to renewables applies to the whole LAC region, its effectiveness and the measures that need to be taken - including through counter-cyclical policies on prices to maintain commercial returns for renewables - have to be adapted to country circumstances and realities

It is also important to stress that the LAC region is a net oil energy exporter (see Table 3B). Indeed, in 2012, for the LAC region net energy exports (mainly fossil fuels) represented almost 25% of total energy use. Using this indicator, the largest net exporters of energy were Colombia, Venezuela, Bolivia, Trinidad and Tobago, Ecuador - and far below - Mexico (see Table 3B).

In 2012 use of oil products represented 11 % of all electricity production for Latin America and Caribbean (LAC) overall, compared to around 4% for the world, 2% for the European Union, and 1% for North America (see Annex 1). Therefore, the impact of the price of oil on the production and installation of renewables in LAC was likely to be much larger than in those regions, if everything else is equal. As we can see in Table 4A, the overall share of production of oil in the total production of energy has been decreasing in the LAC region, though with important country variations.

Meanwhile the total electricity production from fossil fuels in the LAC region averaged around 40% in 2012, with natural gas representing around 23% of the total, and coal almost 6% (see Table 2). Therefore, given the significance of fossil fuels in total production, fluctuations in the price of fossil fuels can have a considerable impact on incentives for investing in renewables, unless an appropriate policy framework is adopted which contains counter-cyclical elements, as we discuss above and below

The region has been increasing the share of renewables, in the total production of energy, quite significantly, albeit from a low base. As can be seen in Table 4, the share of renewables for the LAC region grew systematically from 2.2% in 1990 to 4.8% in 2012. Furthermore, as can be seen clearly in table 2, the countries with the highest proportion of renewables (excluding hydro-electric) in total electricity production are El Salvador, Nicaragua, Costa Rica, Guatemala, Uruguay, Chile, Brazil and Jamaica.

Table 2
Electricity production from different sources[b]
(Percentage of total in 2012)

Country Name	From oil sources	From natural gas sources	From coal sources	From renewables, excluding hydroelectric	From hydro-electric sources
Latin America and the Caribbean (average)	11.2	23.3	5.6	4.8	49.2
Argentina	14.9	53.9	2.7	2.0	21.7
Bolivia (Plurinational State of)	2.0	64.2	0.0	3.1	30.7
Brazil	3.5	8.5	2.6	7.3	75.2
Chile[a]	8.0	16.0	41.9	7.4	26.6
Colombia	0.6	14.4	5.5	3.2	76.3
Costa Rica	8.2	0.0	0.0	20.7	71.1
Cuba	45.6	11.3	0.0	3.1	0.6
Dominican Republic	51.6	24.8	12.9	0.2	10.5
Ecuador	34.9	10.2	0.0	1.3	53.6
El Salvador	36.0	0.0	0.0	32.6	31.5
Guatemala	20.0	0.0	13.2	19.5	47.4
Haiti	86.1	0.0	0.0	0.0	13.9
Honduras	54.6	0.0	1.7	7.0	36.7
Jamaica	91.2	0.0	0.0	5.3	3.5
Mexico[a]	16.0	55.6	10.8	4.4	9.4
Nicaragua	57.2	0.0	0.0	32.4	10.4
Panama	29.0	0.0	8.1	0.3	62.6
Paraguay	0.0	0.0	0.0	0.0	100.0
Peru	3.6	39.2	2.0	1.7	53.5
Trinidad and Tobago	0.3	99.7	0.0	0.0	0.0
Uruguay	38.2	0.1	0.0	10.6	51.1
Venezuela (Bolivarian Republic of)	15.5	19.7	0.0	0.0	64.8

Source: World Development Indicators database. IEA Statistics.
[a] Data from 2013.
[b] Oil refers to crude oil and petroleum products. Gas refers to natural gas but excludes natural gas liquids. Coal refers to all coal and brown coal, both primary (including hard coal and lignite-brown coal) and derived fuels. Hydropower refers to electricity produced by hydroelectric power plants. Electricity production from renewable sources includes geothermal, solar, tides, wind, biomass, and biofuels.

Table 3A
Electricity production from oil sources[a]
(Percentage)

Country name	1990	2000	2006	2007	2008	2009	2010	2011	2012	2013
Latin America and the Caribbean (average)	17.1	15.9	11.3	11.8	12.0	11.3	10.6	10.5	11.2	n/a
Argentina	9.8	3.2	7.5	10.2	11.8	11.7	13.3	15.1	14.9	n/a
Bolivia (Plurinational State of)	8.6	0.8	1.7	1.8	1.7	1.7	1.9	1.6	2.0	n/a
Brazil	2.2	4.3	3.0	3.0	3.8	3.1	3.1	2.8	3.5	n/a
Chile	9.6	4.3	4.9	25.3	26.9	20.0	14.0	9.7	8.8	8.0
Colombia	1.0	0.2	0.2	0.3	0.3	0.6	0.8	0.2	0.6	n/a
Costa Rica	2.5	0.9	6.1	8.0	7.1	4.8	6.7	8.8	8.2	n/a
Cuba	87.5	57.1	45.3	40.9	44.1	38.6	39.5	44.5	45.6	n/a
Dominican Republic	88.7	88.1	64.5	61.4	63.1	62.2	57.7	56.5	51.6	n/a
Ecuador	21.5	28.3	35.9	31.2	29.5	38.5	43.2	35.0	34.9	n/a
El Salvador	6.8	41.9	42.6	43.8	37.5	43.7	35.0	34.0	36.0	n/a
Guatemala	8.4	39.4	31.2	39.5	31.5	42.8	23.0	22.6	20.0	n/a
Haiti	20.6	48.3	52.5	67.1	62.8	71.3	69.8	87.3	86.1	n/a
Honduras	1.7	38.1	63.1	62.4	62.0	55.2	52.2	54.9	54.6	n/a
Jamaica	92.4	95.2	96.1	95.0	93.9	92.6	92.3	91.3	91.2	n/a
Mexico	53.6	46.2	22.1	20.7	18.9	17.5	16.2	16.4	18.9	16.0
Nicaragua	38.6	78.6	69.9	71.0	64.5	69.1	63.0	66.0	57.2	n/a
Panama	14.7	29.6	39.8	43.1	37.9	43.6	43.2	41.1	29.0	n/a
Paraguay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	n/a
Peru	21.5	12.3	6.1	3.0	6.0	5.4	5.8	6.0	3.6	n/a
Trinidad and Tobago	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.3	0.3	n/a
Uruguay	5.1	6.6	35.1	12.9	39.0	31.0	11.7	27.1	38.2	n/a
Venezuela (Bolivarian Republic of)	11.5	9.0	12.6	11.5	12.5	13.0	15.2	14.3	15.5	n/a

Source: World Development Indicators database. IEA Statistics.
[a] Sources of electricity refer to the inputs used to generate electricity. Oil refers to crude oil and petroleum products.

Table 3B
Energy imports, net in 2012[b]
(Percentage)

Country Name	Energy imports, net
Latin America and the Caribbean (average)	-24.8
Argentina	6.3
Bolivia (Plurinational State of)	-135.9
Brazil	10.6
Chile[a]	63.9
Colombia	-294.2
Costa Rica	47.9
Cuba	51.5
Dominican Republic	89.4
Ecuador	-98.6
El Salvador	47.5
Guatemala	25.6
Haiti	18.2
Honduras	51.7
Jamaica	82.2
Mexico[a]	-19.1
Nicaragua	43.7
Panama	78.2
Paraguay	-50.7
Peru	- 7.6
Trinidad and Tobago	-107.0
Uruguay	60.0
Venezuela (Bolivarian Republic of)	-160.9

Source: World Development Indicators database. Source for database: IEA Statistics.
[a] Data from 2013.
[b] Net energy imports are estimated as energy use minus production, both measured in oil equivalents. A negative value indicates that the country is a net exporter. Energy use refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport.

Table 4
Electricity production from renewable sources, excluding hydroelectric[a]
(Percentage)

Country name	1990	2000	2006	2007	2008	2009	2010	2011	2012	2013
Latin America and the Caribbean (average)	2.2	2.2	2.7	3.1	3.2	3.6	4.3	4.3	4.8	n/a
Argentina	0.2	0.8	1.6	1.5	1.3	1.1	1.8	1.7	2.0	n/a
Bolivia (Plurinational State of)	1.4	1.4	1.4	1.0	1.5	1.5	3.7	3.6	3.1	n/a
Brazil	1.7	2.2	3.6	4.2	4.5	5.1	6.5	6.6	7.3	n/a
Chile	5.2	2.3	2.6	4.6	5.2	7.2	4.3	7.6	7.5	7.4
Colombia	0.8	1.2	1.1	1.1	1.1	1.0	4.1	3.3	3.2	n/a
Costa Rica	0.0	17.0	18.0	17.2	14.9	17.6	17.5	18.7	20.7	n/a
Cuba	9.6	6.3	2.5	2.4	3.2	3.1	2.7	2.7	3.1	n/a
Dominican Republic	0.7	0.4	0.2	0.3	0.2	0.2	0.2	0.2	0.2	n/a
Ecuador	0.0	0.0	1.5	1.3	1.2	1.3	1.4	1.5	1.3	n/a
El Salvador	18.9	23.3	22.7	26.3	28.4	30.3	30.2	31.3	32.6	n/a
Guatemala	13.0	10.0	11.5	13.0	13.3	16.6	20.6	19.0	19.5	n/a
Haiti	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	n/a
Honduras	0.0	0.0	2.4	2.7	3.0	2.5	2.4	4.1	7.0	n/a
Jamaica	4.0	3.1	1.7	2.3	2.4	4.2	4.2	5.2	5.3	n/a
Mexico	4.4	3.7	3.6	3.9	3.7	3.9	3.9	3.6	4.2	4.4
Nicaragua	33.7	12.5	20.2	19.5	19.6	22.3	23.2	22.4	32.4	n/a
Panama	2.1	0.5	0.4	0.3	0.2	0.3	0.3	0.3	0.3	n/a
Paraguay	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	n/a
Peru	1.0	0.8	1.3	1.4	1.4	1.4	1.9	1.7	1.7	n/a
Trinidad and Tobago	0.9	0.4	0.6	0.2	0.3	0.2	0.0	0.0	0.0	n/a
Uruguay	0.8	0.5	0.9	1.5	9.6	9.4	8.8	9.4	10.6	n/a
Venezuela (Bolivarian Republic of)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	n/a

Source: World Development Indicators database.IEA Statistics.
[a] Electricity production from renewable sources, excluding hydroelectric, includes geothermal, solar, tides, wind, biomass, and biofuels.

To clarify some of the main electricity production structures of LAC countries, we have created a matrix that classifies countries, as seen in diagram 1. This serves as a typology of countries as regards their energy structures, which gives a framework for analyzing policy options, particularly for scenarios of different levels of fossil fuel prices, including measures to stabilize risk-adjusted returns for renewables.

Diagram 1
Matrix on electricity production and oil production for Latin America

Source: EIA database on oil producers.

A number of Central American and Caribbean countries (Jamaica, Haiti, Nicaragua, Honduras, Dominican Republic and Cuba) have the largest share of oil products for electricity production; this tends to consist both of fuel oil and diesel, much of it off-grid. Of course oil producers and exporters, like Ecuador, Mexico and Venezuela, also have quite a large share of oil in their production of electricity. It is interesting that other small Central American and Caribbean countries have the largest share of renewables (excluding hydroelectric) in the region - this includes El Salvador, Nicaragua, Costa Rica, Guatemala – as well as Uruguay, Chile and Brazil having significant renewable sectors. Looking at extremes, Venezuela, which heavily subsidizes consumption of oil, used 0% renewables (excluding hydroelectric) in 1990 and still had 0% in the 2000s, although it did produce 64.8% of its electricity from hydroelectricity in 2012 (see again Tables 2 and 4). At the other extreme, Costa Rica is impressive because its share of renewables (excluding hydroelectric) shot up from 0% in 1990 to about 20% in 2012, while it produced around 71% of its electricity from hydroelectricity in 2012.

It is interesting that cooperatives have played such an important and positive role in Costa Rica's development of renewable energy. This country, which has committed to becoming "carbon neutral" by 2021, has four electricity co-operatives with over 180,000 members. These provide electricity to more than 800,000 homes, mostly in rural areas and represents 15% of the total electric distribution market in the country. Three Costa Rican co-operatives also jointly own a wind farm (Shaw 2015).

One key issue when discussing electricity production is access, especially as in the Caribbean it can vary so widely. Haiti has the lowest electrification rate in the region and the largest number of people without access to electricity - over 8 million. Distributed generation is the most favorable way to increase electricity access in Haiti and in many of the other countries in the sub-region given their geographies. The Caribbean is rich in solar resources, and falling prices could make solar PV an ideal choice to address this challenge. Some countries in the sub-region have good wind, biomass, and small hydropower resources, providing more alternatives (see table 5).

Table 5
Renewable energy potential in Latin America and the Caribbean countries

Country	Hydro Potential	Wind Potential	Solar Potential	Geothermal Potential	Biomass and Waste Potential
Argentina	HIGH	HIGH	HIGH	HIGH	HIGH
Bahamas	UNKNOWN	MEDIUM	HIGH	UNKNOWN	MEDIUM
Barbados	LOW	HIGH	HIGH	UNKNOWN	LOW
Belize	MEDIUM	HIGH	HIGH	UNKNOWN	UNKNOWN
Bolivia (Plurinational State of)	HIGH	HIGH	HIGH	HIGH	MEDIUM
Brazil	HIGH	HIGH	HIGH	MEDIUM	HIGH
Chile	HIGH	HIGH	HIGH	HIGH	HIGH
Colombia	HIGH	HIGH	HIGH	HIGH	LOW
Costa Rica	HIGH	HIGH	HIGH	HIGH	HIGH
Dom. Republic	HIGH	MEDIUM	HIGH	UNKNOWN	LOW
Ecuador	HIGH	UNKNOWN	HIGH	HIGH	UNKNOWN
El Salvador	HIGH	HIGH	HIGH	HIGH	UNKNOWN
Guatemala	HIGH	HIGH	HIGH	HIGH	HIGH
Guyana	HIGH	MEDIUM	HIGH	UNKNOWN	LOW
Haiti	HIGH	HIGH	HIGH	UNKNOWN	LOW
Honduras	HIGH	HIGH	HIGH	HIGH	HIGH
Jamaica	LOW	MEDIUM	HIGH	HIGH	LOW
Mexico	HIGH	HIGH	HIGH	HIGH	HIGH
Nicaragua	HIGH	HIGH	HIGH	HIGH	HIGH
Panama	HIGH	HIGH	HIGH	UNKNOWN	UNKNOWN
Paraguay	HIGH	HIGH	HIGH	UNKNOWN	MEDIUM
Peru	HIGH	HIGH	HIGH	HIGH	MEDIUM
Suriname	HIGH	LOW	HIGH	UNKNOWN	LOW
Trinidad and Tobago	LOW	LOW	HIGH	UNKNOWN	LOW
Uruguay	HIGH	HIGH	HIGH	UNKNOWN	MEDIUM
Venezuela (Bolivarian Republic of)	HIGH	HIGH	HIGH	LOW	HIGH

Source: Flavin et al. 2014: 19.

Nevertheless, Caribbean countries are dominated mainly by oil and diesel electricity generation. Because most of these countries do not have local oil or natural gas resources, and are too small to burn coal cost effectively, they are subject to oil and diesel imports with volatile prices that often result in high electricity tariffs. Jamaica is a prime example, with average retail tariffs in 2006 much higher than elsewhere in Latin America and the Caribbean (Flavin et al, 2014). This makes renewable energy potentially attractive in the sub-region, yet such development is limited due to a lack of economies of scale as well as fossil fuel subsidies with high fiscal costs. Meanwhile, some Caribbean nations ─including Trinidad and Tobago─ have abundant fossil fuel resources that have suppressed the development of renewable energy and have kept electricity tariffs low.

It is important to stress that, as Flavin et al. (op cit.) and other sources point out (Vergara et al. 2013), in global terms, Latin America and the Caribbean has among the most extensive and diverse supply of renewable energy resources of any region, but this potential has only begun to be tapped (See table 5, for country-by-country potential for different types of renewables). Even excluding hydropower, which is not yet fully exploited, the region could produce, according to estimates, 78,000 TWh more of electricity from renewable energy sources (Flavin et al, op cit.). This is enough capacity, if combined with hydropower, to meet the region's current (1,400 TWh) and future (2,500 TWh) electricity needs many times over. Indeed, by exploiting less than 2% of the available technical potential the full current electricity demand could be met (Vergara et al. 2013: 9).

However, the Andean Zone, formed by Bolivia, Colombia, Ecuador, Peru, and Venezuela, is composed of major oil and natural gas producers, a factor that has shaped its electricity mix. As pointed out, Venezuela has no renewable electricity production outside of hydroelectricity. In the early 1990s, the Andean Zone followed the global trend of power market liberalization pioneered by neighboring Chile from 1982 and emulated globally from the United Kingdom and parts of the United States and Australia. Recently, however, many countries in the Andean region including Bolivia, Venezuela, and Ecuador have implemented reforms championing a reversal to more regulation, resource nationalization and further state control of the energy sector.

Since 2006, Bolivia has nationalized its energy sector, with the goal of offering equitable service. In 2012, two private distribution companies were expropriated. In 2007, Ecuador created new centralized national energy companies to consolidate electricity distribution. Centralized, state-owned companies have controlled the electricity market in Venezuela since 2007.

Colombia and Peru still have liberalized power markets with significant private participation and unbundled electricity generation, transmission, and distribution. In Colombia, electricity is centrally dispatched by a system operator; it is based on day-ahead bids made by generators. In Peru, electricity is commercialized, through public and private utilities, as well as by some generation companies directly.

In the Southern Cone region, Chile has the most diversified electricity mix: in addition to natural gas and hydropower, it relies on oil, coal, small hydro, wind, and biomass. Uruguay's wind and biomass make it the South American country with the highest proportion of renewables excluding hydroelectricity (see again table 3A). Uruguay also has major plans to dramatically increase renewable electricity production through development of its wind sector.

Chile is looking to cut its emissions of carbon from power generation and has established a voluntary target for a 20% reduction from 2007 levels by 2020 under the UNFCCC. In Chile all generation, transmission, and distribution in the country has been privatized. In Uruguay's case transmission and distribution sectors are public, and there is very little private participation in generation (6% of installed capacity).

In the Southern Cone, Chile plays a leading role in the development of renewable energy, with more than 10.1 GW in the pipeline. It has strong renewables potential, high energy demand growth, high electricity prices and a liberalized power market. However, its power system is supported by four separate systems and connecting energy demand to where renewable supply is high (for example solar in the North) is a critical challenge to furthering Chile's development of renewables.

F. Policies to support renewable energy in Latin America and the Caribbean

To help define policies that will help continued growth in renewable energy investment in the face of different levels of fossil fuel prices, and especially a possible prolonged low level of such prices, we need to understand the current set of policies that support renewable energy in different countries in LAC. We outline these in this section.

1. Renewable electricity targets

Ten countries in LAC, as of 2014, set official targets for increased deployment of renewable energy technologies (see table 6). These have several forms. In Argentina, Barbados, and Peru renewable energy targets are based on the share of consumption; in Chile, the Dominican Republic, and Mexico they are based on the share of generation. In Jamaica, Nicaragua, and Uruguay they are based on the share of capacity installed. The ambitiousness of these goals varies widely. For example, while Jamaica aims to achieve 20% renewable capacity by 2030, Nicaragua committed reaching 94% by the same year.

Table 6
Renewable electricity targets in selected Latin America and the Caribbean countries

Country	Renewable Electricity Target
Argentina	8% of consumption by 2016
Barbados	29% of consumption by 2029
Chile	10% of generation by 2024
Colombia	3.5% of on-grid and 20% of off-grid generation by 2015
Dominican Republic	10% of generation by 2015; 20% by 2025
Jamaica	20% of capacity by 2030
Mexico	35% of generation by 2024
Nicaragua	94% of capacity by 2017
Peru	5% of consumption by 2013
Uruguay	15% of capacity by 2015

Source: Flavin et al. 2014: 31.

2. Renewable energy auctions

Renewable energy tenders or auctions are procurement mechanisms by which public actors solicit bids to supply a given amount of renewable energy capacity. Nine of the twenty six countries in the region had implemented auctions for renewable energy technologies by 2014.

Brazil integrated auctions in its regulatory framework in 2004 and has used them since, offering long-term, 20-year contracts ahead of delivery for the regulated market. The original motivation behind introduction of auctions was price disclosure and efficiency in the procurement process. Since 2005, 25 auctions - of which 9 were exclusive to renewable energy - have been carried, of which 60% was renewable (40% conventional hydro and 20% other renewables).

Peru held technology-specific auctions for small hydro, solar, wind, biomass, and geothermal since 2009. These auctions offered 20-year power purchase agreements (PPAs), with an expectation to yield an annual 12% rate of return based on a ceiling price determined by the Peruvian electricity regulator. According to Flavin et al. (op cit.) the Peruvian auctions have been largely successful and have been the only auctions in the region to successfully auction solar contracts, and they have brought down the prices of other renewable technologies.

Other countries implementing auctions in the LAC region include Argentina, Costa Rica, Guatemala, Honduras, Panama, Uruguay and Jamaica.

It is interesting that many other countries, both emerging - including India and China - as well as more developed like UK and Ireland have implemented fairly successfully so-called reverse auctions (for an in-depth analysis and evaluation of the Indian case, see Altenburg et al., 2012).

These competitive reverse auctions typically have two objectives in all countries: mobilizing investors and finding out information about necessary rents, which determines minimal tariff rates at which investors will pursue renewable projects. This allows governments to reduce tariffs ─and thus public subsidies─ at a given price of energy. One possible problem is if winners of the auctions do not materialize their investments due, for example, to lack of experience. Another issue is that bidders have incentives to bid at very low levels, which may not offer a sustainable level of return over the project lifetime, leading to solvency issues down the line. This may be remedied once investors become more experienced. The former problem may also be reduced by requiring investors to put down some capital at the time of bidding, which they then have to use if they win the bid (interview material).

3. Feed-in tariffs

Feed-in tariffs (FiTs) set a fixed price at which renewable energy can be sold and fed into the grid, guaranteed over a certain period. Although their design varies according to the context in which they are implemented, FiT policies aim to incentivize renewable generation by providing market certainty and stability. Use of FiT mechanisms in Latin America and the Caribbean has been less widespread than in other regions, in part because most governments already subsidize electricity for low-income consumers. The costs of implementing FiTs are seen to further burden national budgets, but this could be overcome if fossil fuels subsidies are reduced or fossil fuels are taxed more, as discussed above.

The recent challenges surrounding FiTs in Europe (especially in the German case, but also others, interview material) has also meant that countries in Latin America and the Caribbean are careful to avoid the mistakes of early adopters in Europe who had to revise tariffs to account for changes in the cost of renewables as well as other factors. When designing a FiT, it is important to account for the reduction in costs over time of renewable energy technologies, as Germany has done.

Nevertheless, several countries in the LAC region moved forward with the FiT model. Argentina and Dominican Republic approved legislation. Honduras and Panama offer price premiums for electricity generators that sell to the main utility. Uruguay used them for contracts for electricity from biomass. Nicaragua implemented a FiT for all renewable energy sources. Brazil’s Programme of Incentives for Alternative Energy Sources (PROINFA) and Ecuador’s FiT program guaranteed above-average market prices for renewable projects; both programs ended.

The model implemented by PROINFA in Brazil differed somewhat from traditional FiT policies seen in Europe. The mechanism set the target of contracting renewable generation capacity, equally from wind, biomass, and small hydro. The costs of the scheme were levied from customers on electricity bills.

It is interesting that if a counter-cyclical approach to supporting prices for renewables, this could easily be channeled through such FiT programs, in countries where these exist.

4. Quota obligations

Quota obligations require certain actors to meet a minimum target for renewable energy. Chile is the only country in the region that uses a utility quota obligation. The law mandates electric utilities with more than 200 MW of operational capacity generate 20% of electricity from renewable sources by 2025.

Again counter-cyclical policies on prices to maintain renewable risk-adjusted returns could be made consistent with quotas, though implementation would be less direct than with FiTs, but could be channeled through for example new subsidies or reduced taxes.

Other quota obligations in the region concern biodiesel and ethanol blending mandates for conventional diesel and gasoline respectively, more relevant for transport.

5. Net metering

Net metering policies allow utility customers to install their own renewable systems and feed the electricity they produce back into the grid, reducing their electricity bills. In LAC, as of 2014, eight countries adopted net metering policies.

For example, Barbados adopted a program where customers may generate renewable electricity up to a maximum of 1.5 times their monthly energy consumption and sell the excess to the national utility for an assured 10 years. Brazil implemented a program for small-scale power generation for retail electricity customers, allowing them to install self-generation facilities interconnected with the utility grid.

Chile approved net billing legislation for renewables. In Costa Rica, the net-metering pilot program allows individual consumers to connect systems up to the size of their annual electricity consumption with 15-year contracts. The Dominican Republic, Jamaica, Mexico and Uruguay also implemented metering programs.

6. Fiscal incentives

Fiscal incentives of various forms represent the most commonly applied mechanism to support renewable energy deployment in the region. They are currently being used by a majority of countries in the LAC region (see table 7 below). The most prevalent fiscal incentives are tax relief for renewable energy generators and import duty exemptions for renewable energy equipment. Argentina and Mexico implemented accelerated depreciation, while Dominican Republic, El Salvador, Guatemala, Honduras, and Nicaragua implemented income tax reductions for renewable energy generation projects (Flavin et al, op cit.).

Existing tax subsidies in the different LAC countries could, in most cases, be suitably adapted to incorporate a counter-cyclical policy response to the variations in the price of fossil fuels. It would seem, for example, that the easiest to adapt would be tax relief for renewable energy generators. We return to these issues briefly below, but further research is required for this important topic.

7. Public funds for renewable energy projects

Several LAC countries have mechanisms to funnel public funds to support renewable energy projects, often financed by resources from oil revenues. We will come back to this issue below, analyzing if and how such mechanisms could be expanded, when we discuss broader policy measures to encourage greater investment in renewables.

In Brazil, BNDES FINEM created a credit line for renewable energy projects in 2004, providing low interest rates for loans financing up to 80% of total project costs, amortized over 16 years. In 2012, BNDES created another credit line, also subsidized, for the same purpose. It is noteworthy that part of the Fund comes from Brazil's oil exploration revenues.

In Mexico, two separate funds aim to support renewable energy technologies. The Mexico Sustainable Energy Fund receives 20% of the revenue raised by an annual tax of 0.65% on Petroleos Mexicanos (PEMEX), Mexico's state-owned oil company for oil and natural gas extraction. Mexico's National Council on Science and Technolog (CONACYT) holds periodic tenders to choose Mexican institutions that develop the fund's research and technology projects.

Similarly, the Mexico Energy Transition and Sustainable Use of Energy Fund aims to encourage renewable energy development by promoting initiatives favoring the transition to a more sustainable use of energy, energy efficiency, and renewable energy technologies.

Table 7
Fiscal incentives for renewable energy in Latin America and the Caribbean countries

Country	Accelerated Depreciation	Tax Relief	Income Tax	Import Duty	Tax Rebate	Other
Argentina	Yes	No	No	No	Yes	No
Bahamas	No	No	No	No	No	No
Barbados	No	No	No	No	No	No
Belize	No	No	No	No	No	No
Bolivia (Plurinational State of)	No	No	No	No	No	No
Brazil	No	Yes	No	Yes	Yes	No
Chile	No	No	No	No	No	Yes
Colombia	No	Yes	No	No	No	No
Costa Rica	No	Yes	No	No	No	No
Dom. Republic	No	Yes	Yes	Yes	No	No
Ecuador	No	Yes	No	No	No	No
El Salvador	No	No	Yes	Yes	No	No
Guatemala	No	Yes	Yes	Yes	No	No
Guyana	No	No	No	No	No	No
Haiti	No	No	No	No	No	No
Honduras	No	Yes	Yes	Yes	No	No
Jamaica	No	No	No	No	No	No
Mexico	Yes	No	No	No	No	No
Nicaragua	No	No	Yes	Yes	No	Yes
Panama	No	Yes	No	Yes	No	Yes
Paraguay	No	No	No	No	No	No
Peru	No	No	No	No	No	No
Suriname	No	No	No	No	No	No
Trinidad and Tobago	No	No	No	No	No	No
Uruguay	No	Yes	No	No	No	No
Venezuela (Bolivarian Republic of)	No	No	No	No	No	No

Source: Flavin et al. 2014: 34.

II. The impact of different levels of future oil prices and evolution of the cost of renewables on future private investment in renewables

Three broad scenarios can be defined for the price of oil and other fossil fuels: a) Current prices or slightly higher, b) Lower price than current and c) Return of significantly higher prices.

It is difficult to forecast short, and even more medium or long-term, trends for the price of oil as well as other fossil fuels. There are factors which affect the price of oil originating in the real economy, such as total demand for energy, linked to global growth and the structure of such growth. Limits to GHG emissions, that hopefully will be increasingly agreed, could pose constraints on the future growth of demand of oil and other fossil fuels. Reductions in the cost of renewables may also diminish demand for fossil fuels.

There are also factors linked to the supply of oil and its cost. These are, for example, influenced by new discoveries of resources and by technological progress. Supply is also influenced by the existence or resolution of conflicts, with for example the end of the Iranian sanctions being given as an important factor for recent increased supply of oil in world markets.

Last but not least, oil especially (but also to a certain extent natural gas) has become a major financial asset increasingly traded on financial markets, for example through index traders in financialised commodity futures markets. This adds a new - and especially hard to predict - determinant of prices, a new source of volatility, as well as a possible tendency to exaggerate cycles of prices.

The current projections by the IMF forecast a very gradual increase of nominal prices from current low levels, of an estimated average of $57 per barrel average spot price for 2015, to an estimated $69 for 2020. The World Bank forecast a similar, but very slightly higher, increase in nominal prices (Knoema, 2015). These forecasts imply almost no increase in real terms for the next five years.

An additional important factor in predicting oil prices is the super-cycles of commodity prices. Writing in the tradition of Kondratiev, Schumpeter (1939) and more specifically Prebisch and Singer, Erten and Ocampo (2012) have described major super-cycles in commodities prices, including of oil prices, since the second half of the 19th Century. Krugman (1998) and Blanchard (1997) have also written about medium term cycles of commodity prices. The extent to which the current decline in commodity prices, and indeed of fossil fuel prices, is at least part of the end of one of these super-cycles needs to be considered more deeply.

A key conclusion, looking at past and likely future trends, is that future levels of oil and other fossil fuel prices are likely to be both uncertain and volatile. This in itself provides an important incentive for investment in renewables, whose costs of installation are likely to continue declining, and where the cost of the energy inputs (such as sun and wind) are typically zero. However, uncertainty about oil prices is also a double-edged sword, as it may ─by making the profitability of renewables less certain─ also discourage private investment in them.

To the extent that oil and other fossil fuel prices remain at current levels or slightly lower ─and they are expected to continue at or close to current levels for a relatively long period, by institutions such as the IMF and the World Bank─ there will clearly be a strong disincentive for the levels of private investment in renewables to remain at current fairly high levels, let alone for them to be increased, **unless policy measures are taken to compensate for these trends.**

One of the key policy recommendations is that existing policies (such as FiTs, auctions, quotas, tax subsidies, public support and others) need to be complemented and/or modified to include counter-cyclical elements related to the price of fossil fuels to encourage investment in renewables. This would ensure that the risk-weighted profitability of renewables would be stabilized, independently of the price of renewables at levels sufficiently high to encourage growing investment in them, without allowing for excessively high profits.

Thus when the price of oil or the most important fossil fuel in a particular country falls significantly, it may be desirable to cut subsidies of fossil fuels and/or raise taxes on them and use those revenues to subsidize renewables, for example through Feed-in Tariffs or other mechanisms, as well as possibly funding research to lower their cost and increase their reliability. This could build and expand significantly on the type of measures already implemented in Brazil and Mexico, discussed in section II.5 above, where taxes on fossil fuels are used to provide subsidized credit to renewables or to fund research on innovation in renewables. Furthermore, if and when the cuts in fossil fuel subsidies raise the cost of energy for low-income consumers, they would need to be compensated in advance of any measures that could increase the price of electricity for them.

When the price of the same relevant fossil fuels goes up significantly, taxes on fossil fuels could be reduced, as would subsidies to renewables, as renewables would become again more commercially competitive without, or with less, support. Rules could be defined ex-ante, to increase predictability, but adjusted to the scale of fluctuation to prices of the relevant fossil fuel, as well as to other major changes such as in the average cost of new renewable plants. However, it would seem desirable not to increase subsidies to oil and other fossil fuels, even if their price goes up, so as to reduce the incentives for fossil fuel powered electricity, due to all the negative externalities arising from fossil fuel use, especially for climate change.

A key positive aspect of such a mechanism is that it would be fully funded in that any additional costs borne by governments in one sector, for example in renewables, would be financed by the other sectors, such as oil and other fossil fuels. A second important positive feature of this is that ─whilst prices of oil and other fossil fuels remain low─ this would provide a valuable policy push for a quick reduction in fossil fuel subsidies, which is clearly desirable for reducing greenhouse gas emissions in a speedy way, as major international organizations like the UNFCC and the IMF have rightly and clearly stressed.

Such policy measures need to be adapted to the particular characteristics of each country and region, and will depend on factors (several of which have been discussed above in some detail) such as the current structure of sources for energy production, the potential for renewables and their likely cost, the likely impact of the increased price of oil and other fossil fuels on the competitiveness of renewables, the existing policies to support renewables, but also broad macro-economic factors, such as the overall fiscal situation. For example, major oil producers and exporters are likely to face a difficult fiscal situation when the oil price is low; thus their fiscal authorities may welcome the idea of reducing large fossil fuel subsidies, part of which could in such a case be used to alleviate fiscal deficits, if needed.

Countries that have public development banks, and especially if these are large in proportion to the country's financial system, can use these to play an important complementary role in providing cheap finance, at sufficient maturity, to encourage greater investment in renewables. Cheap interest costs are indeed a very important aspect, as the cost of renewables is to an important extent front-loaded (e.g. installation of solar), and the operation costs are often very low or zero. As the cost of finance in emerging and developing economies is often fairly high, lower cost of finance, provided for example by development banks, can be a very important source of support for investment in renewables. The level of subsidies for renewables could also vary depending on the price of oil and other fossil fuels.

Naturally, development banks and governments have other key roles to play in supporting investment in renewables. One key example is funding crucial investment in grid expansion, including those for integrating variable and intermittent renewable energy at a reasonable cost in grids that provide energy in a stable and reliable way at a national level. Going beyond this, the LAC region could benefit with greater integration between national grids of different countries, so as to maximize optimum exchange or pooling of intermittent renewable energy, linked to variability of their supply, e.g. strength of wind.

Political economy factors will also be important to help implement policies to support renewable energy. These include the relative weight of the influence of fossil fuel producers, as well as those of renewables producers, and of those committed to a genuine green transformation. Furthermore, such policy measures will both be reinforced by ─and reinforce further─ a strategy of green transformation and commitment to renewables, in countries where such policy directionality exists or can be established (Mazzucato 2013).

Even more broadly, it seems that if found desirable for implementation at a national level, such a counter-cyclical policy approach should also be pursued at a regional and more ambitiously at a global level. This would help support national initiatives in this field, as well as provide possible coordination between different countries' policies. Indeed, it seems essential that there is greater regional and global coordination of policies to be pursued to reach internationally agreed climate change mitigation targets. Clearly an important role, in the suggestion and design of such policies, should be played by relevant UN bodies, such as regional commissions and specialized UN agencies dealing with the environment, as well as multilateral and regional development banks.

III. Chile case study

A. Latin American renewable energy background

As pointed out, Latin America is a region that has a vast amount of natural resources relevant for renewable energy and which have great development potential.

A WWF study has noted that while Latin America and the Caribbean generate about 7% of the world's electricity, nearly 65% of it comes from renewables (WWF 2014). Most comes from hydropower, while non-traditional renewable sources (solar, wind, geothermal, etc.) represent around 5-6 % of the total (see also discussion above). It is hoped that by 2050 more than 20% of the electricity produced in the region will come from non-hydro renewables.

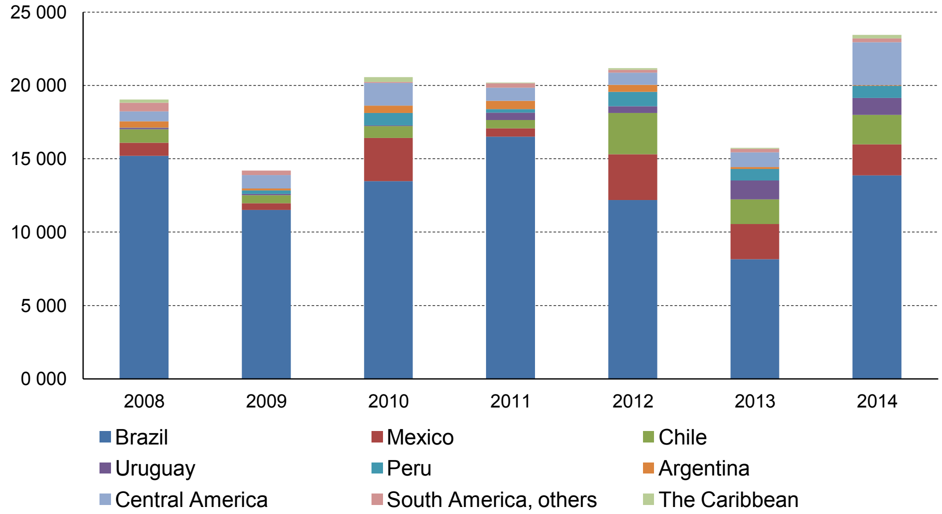
Latin America has become one of the most attractive regions for investment in non-conventional renewable energy. The number of countries in the region which are investing in Non-conventional renewable energy (NCRE) has also increased. In 2012, between 70% and 80% of investments in these projects went to Brazil. However, since then, according to Bloomberg Energy Finance and others (Fomin et al. 2014), other countries have attracted significant investment, like Chile, Uruguay, Mexico, Honduras and Peru, mainly for wind projects (76%), solar (17%), and mini-hydroelectric (7%) (see figure 8 for 2008-2014 period).

As discussed above, renewable energy implementation costs have declined while many Latin American governments have reduced entry barriers through the creation of stable legal environments and state subsidies.

The capacity of renewable energy in Latin America was around 30.8 GW as of 2014, ranking fourth after hydropower (149.7 GW), natural gas (71.4 GW) and oil (48GW). Until 2013, wind energy and biofuels consisted most of the investments in renewable energy, however from 2014 photovoltaic solar energy began to be more relevant.

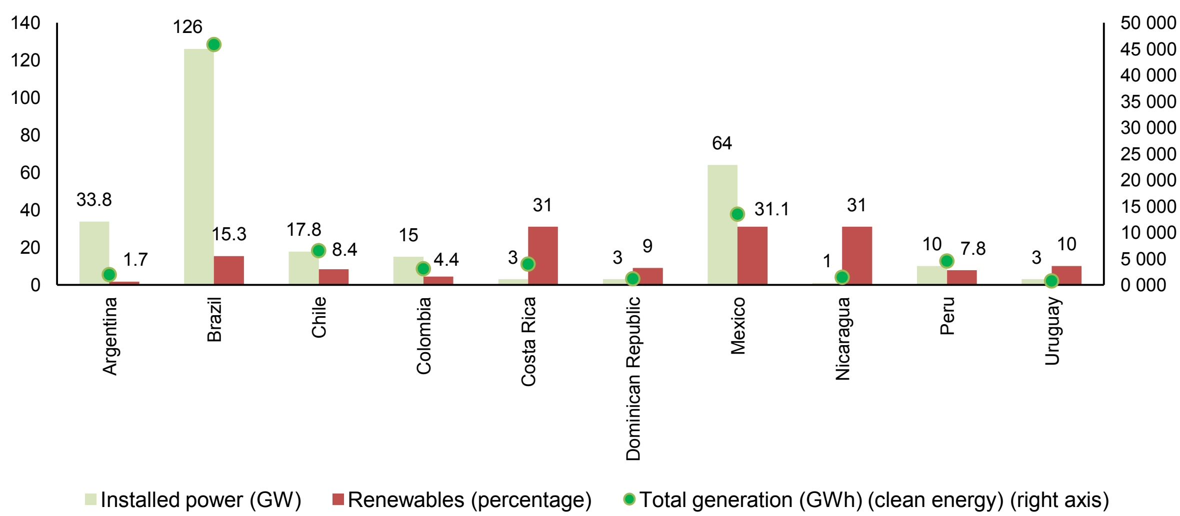
The consultancy firm GTM Research notes that Brazil, Chile, Mexico and Uruguay are among the 10 most active countries in developing renewable energy technologies worldwide (interview material). Figure 9 shows how, in Latin America, the situation varies according to country. Brazil leads the region in terms of the volume of installed capacity and the generation of renewable clean energy. Until 2012 the country attracted around 80% of all NCRE investments in Latin America, but the economic slowdown in the country in recent years has negatively affected lending for new renewable energy projects. Furthermore, 2013 was a bad year for the Brazilian energy system, which largely depends on hydropower production, which was affected by a massive drought.

Figure 8
NCRE investment in Latin America and the Caribbean, 2008-2014
(Million US dollars)



Source: Fomin et al. 2014: 39.

Figure 9
Installed capacity and the total share of renewable clean energy generation in Latin America, 2014



Source: Bloomberg New Energy Finance.

Chile is one of the Latin American countries that is fast developing renewable energy. In 2014 it had a total capacity of 18 GW installed, of which 8% was renewable energy (figure 9). Chile has been in part expanding its renewable energy production because of the establishment of an ambitious energy policy - the Law of Non-Conventional Renewable Energy – which states that 20% of energy should be from renewable sources by 2025. In 2013, US $ 1,600 million was invested in NCRE projects in Chile, of which more than US $ 900 million was for solar and US $ 700 million for wind farms (interview material).

Uruguay and Costa Rica are also notable cases in the region. They are small countries with populations not exceeding three and five million respectively. However, both countries have implemented a set of energy and environmental reforms aimed at increasing the use of renewables.

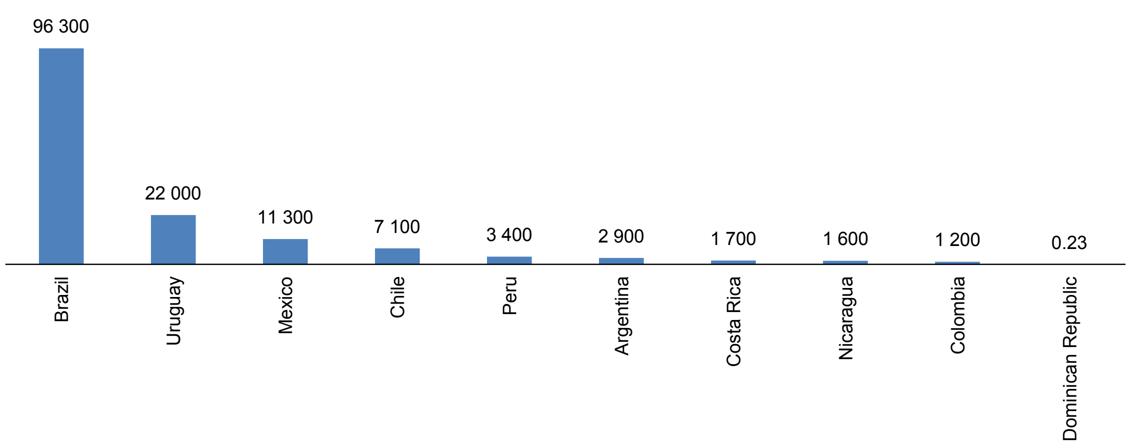
Uruguay has organized numerous bids for contracts for clean energy to reduce its dependence on hydroelectric and fossil fuel plants. In 2014, 10% of its 3 GW total capacity came from renewable energy (figure 9).

Uruguay has a national energy policy which aims to produce 100% of its electricity from renewables by 2030 (mostly hydro), and for 15% of the electricity produced in the country to comes from NCREs by 2020.

Meanwhile Costa Rica aims to be the first country in Latin America to produce 100% of its electricity from renewables, including hydroelectric. It has 3 GW of total installed capacity, of which 31% was from renewables in 2014. The country has developed two systems that facilitate the expansion of renewable energy. The first is a specific system of tenders for projects exclusively dedicated to NCRE, and the second related to a series of tax deductions for machinery used by the renewable energy industry (see also above).

Figure 10 below shows the investments made in renewable energy in Latin America between 2006 and 2014, expressed in millions of dollars:

Figure 10
NCRE investments in Latin America, 2006 - 2014
(Million US dollars)



Source: Bloomberg New Energy Finance.

Fomin et al. (2014) reported that of existing investment in Latin America to promote renewable energy in 2014, over 70% was allocated for the development of new projects. Brazil, for example, is building the largest wind farm in Latin America - the Campos Neutrais complex - consisting of three wind farms in the state of Rio Grande do Sul which will provide energy to 3.7 million people.

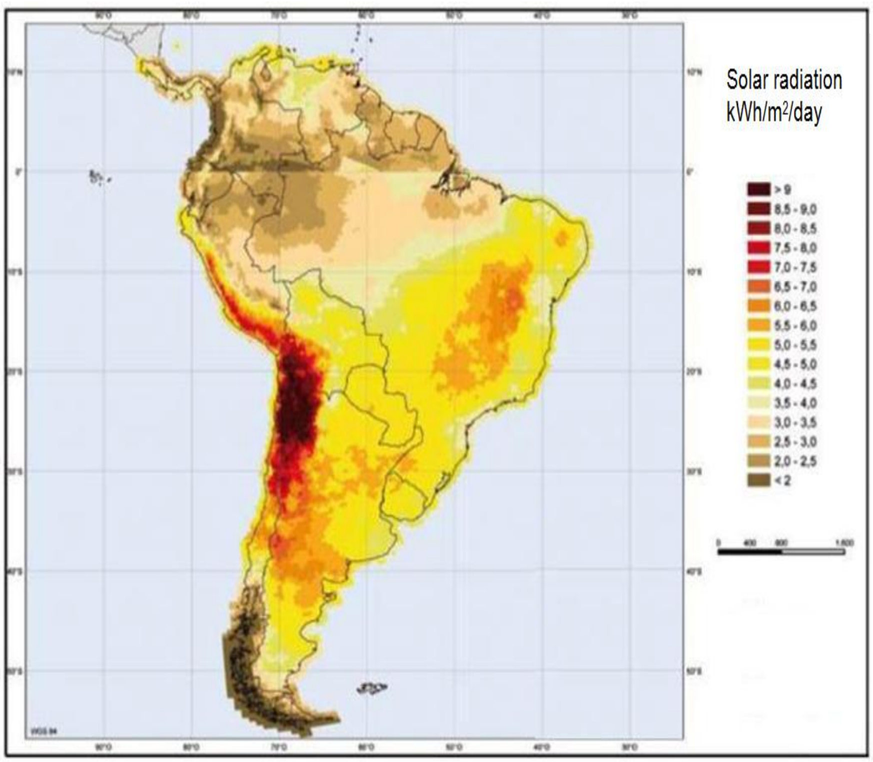
Chile has been building the photovoltaic plant Atacama 1, the largest solar plant in Latin America. The Spanish company Abengoa invested US $ 1,300 million in this project, which will inject 200 MW to the country's Central Interconnected System (SIC).

B. Chilean case study

Chile could become a solar energy world power. The large northern part of the country has very clear skies and a high level of solar radiation (one of the highest rates in the world), and there are vast areas available for solar facilities in the Atacama desert. Due to the high energy consumption of mining concentrated in this area, there is a high local energy demand, and considerable scope to expand solar energy production in the area. Chile is currently looking into the possibility of creating a solar cluster permanently linked with the copper mining industry in the north with non-conventional renewable energy.

It is also interesting to note that in South America, Chile is the largest net importer of energy, as proportion of its production of electricity (see table 3B), which gives the country incentives to develop its own renewable sources, both from a balance of payments perspective as well as from an energy security perspective. Furthermore, given the length of the country, and its distance from important supplies of fossil fuels, transport costs of fossil fuel play a more important role than in many other countries, giving renewables a further advantage.

Map 1
Solar radiation in Chile and South America



Source: Reyes, 2015.

Investment in new renewable energy projects in South America is increasingly focused in Chile and Uruguay. According to a Bloomberg (2015) study, 2015 was a record year in terms of photovoltaic solar installations developed in South America, with the majority of these projects developed in Chile. In 2015 Chile had 2,267 MW coming from renewables (CIFES 2015). Table 8 shows the top 10 PV projects in Chile in 2015.

Table 8
Top 10 PV projects in Chile

Name	Size (MWp)	Connection	Finance	Developer	Region	Year
Amanecer Solar	100	SIC	PPA	Sunedison	Atacama	2014
Parque FV Maria Elena	72.8	SING	Merchant	Sunedison	Antofagasta	2015
PV Salvador	68	SIC	Merchant	Sunpower	Atacama	2015
Lalackama 1	60	SIC	PPA	Enel Green Power	Atacama	2015
San Andres	51	SIC	Merchant	Sunedison	Atacama	2014
Chanares	40	SIC	PPA	Enel Green Power	Atacama	2015
Diego de Almagro	36	SIC	PPA	Enel Green Power	Atacama	2014
Pozo Almonte	25	SING	PPA	Solarpack	Tarapaca	2014
La Huayca I, II	9.6	SING	Merchant	Selray Energias	Tarapaca	2015
Los Puquios	3	SING	PPA	Sonnedix	Tarapaca	2014

Source: Elfuturosolar 2015.

Recently approved projects will provide 268.5 MW of solar PV and 110 MW of Concentrating Solar Power (CSP) from the Abengoa plant Atacama II (Electricidad 2015). This will be the largest photovoltaic solar energy plant in Chile – as well as in Latin America - and aims to provide electricity for the entire region. The plant will have 390,000 photovoltaic panels which will power around 85,000 homes. It will have a system of molten salt thermal storage, which will enable the delivery of stable 24 hours a day energy supply from the plant. Both plants will prevent the emission of 870,000 tons of CO2 per year if built, and will aim to cover energy demand for residential and industrial use (interview material).

Another project being prepared is the Copiapo Solar project, which should become operational in 2019, offering 260 MW to consumers of the Central Interconnected System (SIC) (Hergueta 2015). The project draws on the "Crescent Dunes Solar Reserve" of the United States, which is already active. To obtain permits for the project in Chile, the company collaborated with stakeholders and local communities in order to ensure that the environmental impact would be minimal. This consultation involved a careful selection of the land to be used to minimize water use, as well as extensive studies before construction work began to assess potential environmental impacts. The Copiapo Solar project underwent the Chilean System of Environmental Impact Assessment (SEIA), and received an Environmental Qualification Resolution (RCA), which is necessary to operate in Chile in such cases (Hergueta 2015).

Between 2015 and 2019, 6 GW of NCRE is planned to be created in Chile, of which half would be solar and wind energy, and the other half would be divided between hydropower and other energy sources. According to the June 2015 report on the state of NCREs in Chile (CIFES 2015), the country at that time had 2.257MW under construction and 2.267MW in operation of renewable energy.

1. Challenges for renewables and policy responses for Chile

The Chilean government has provided facilities for the location of electricity projects and has also called for tenders for renewable energy; as a result, various innovative and profitable projects are being constructed in the country. In late 2015 the last tender resulted in a price of US $75 MWh, which was under half the previous tender result, at US$ 160 MWh (interview material).

Among the main obstacles to the development of photovoltaics in Chile are deficiencies in the transmission network, as it has major weaknesses and low transmission capacity from the north to the south of the country. Indeed, during many times of the day the spot price drops to zero, because users cannot receive more energy. This situation should improve in the medium term, which will facilitate the installation of more photovoltaic plants. Indeed, according to Roberto Román, an expert in solar energy: "The major constraint for photovoltaic energy in Chile is the transmission network and how this network will join existing ones, as currently Chile still lacks an integrated electrical connection system at the national level" (interview material).

Indeed, a key challenge in Chile, as elsewhere, is the variability and intermittence of electricity generation, based on renewables, which obliges companies using these - e.g. in the large copper mining industry in the North of Chile - to use combined cycles of renewable and fossil fuel energy when the former is not available, given that the energy generated is directly connected to the mining production. If the renewable energy were to be injected directly through the transmission network, this would need to be expanded and/or built, which would add significantly to cost of renewables.

Also in the medium term, there should be a substantial increase in technical expertise in the area in order to meet the needs that require the installation of plants of this type of energy.

Another barrier for photovoltaics is the large lobbying carried out by coal companies so that their companies do not go bankrupt when these new energies come in.

This situation is compounded by almost no research on photovoltaic energy in the country that could begin generating and adapting new technological solutions and products, with a view to later export them. Local, exportable innovations would be helpful in applications, software, business models – rather than the sophisticated core hardware. The key equipment underlying a PV plant are PV modules and grid-tied inverters, which both have highly competitive, globalized supply chains. Almost all equipment will likely come from China for the foreseeable future.

An alternative to stabilize the production of energy from renewable sources, is to combine technologies, as there are in many countries at least pilot hybrid renewable energy projects: photovoltaic - biomass and photovoltaic - wind power. These type of hybrid projects can generate a stable base for potential investors and it diversifies any volatility in the costs or in supply, which can generate more stability in returns. In the case of photovoltaic - wind power, the energy is especially complementary.

In terms of stabilizing the supply of one type of renewable energy, the CSP technologies are attractive, as they would provide storage capacity, eliminating the problem of intermittence of energy supply. Here, as in other cases, a key issue is that of cost, and the ability of renewable energy to compete with fossil fuels.

Therefore, it is key in Chile, as in other LAC countries, to provide a package of policies that will consistently support investment in renewables, both through measures such as tax incentives or other measures linked to the price of fossil fuels, to maintain competitive risk-adjusted returns. It is also important for countries to follow other policies, like investment in grids, where gaps exist, as well supporting innovation and training where required. For the latter policies, an important role may need to be played by public investment and/or public development banks.

IV. Conclusions and policy recommendations

This paper poses the issue of whether the recent sharp decline in the price of oil and other fossil fuels, should it remain at approximately current levels as is possible if not likely, would serve as an important disincentive to future private investment in renewable energy, especially in the LAC region.

Sufficient investment in renewable energy is one key element for helping achieve the crucial GHG target needed to avoid an increase of temperature above 2 C. It is therefore essential that recent trends of increased investment and production in renewable energy are not only maintained, but increased. In climate change mitigation, time is of the essence, so any reversals would be extremely undesirable.

The increase in private renewables investment worldwide and in the LAC region, have been driven by sharp declines in costs of such investment, as detailed above. This, together with supportive policies to increase the profitability of renewables in many countries, as described above for the LAC region, encouraged investment in the renewables sector. On the other hand, large fossil fuels subsidies, especially in some countries, such as major oil producers, have encouraged high investment and consumption of fossil fuels. The latter is highly undesirable from a climate change mitigation perspective.

The sharp fall in the price of oil and other fossil fuels pose the risk of disrupting the continued investment in renewables, to the extent that they become less and insufficiently profitable. This will be particularly true for those countries where fossil fuels represent an important part of the production of electricity (as is the case in several countries in Latin America).

As discussed in section III, the decline in oil and other fossil fuel prices presents an ideal opportunity for national governments to reduce subsidies to them, without leading to major increases of the price of electricity. For countries not using large subsidies to fossil fuels, governments could increase taxes on fossil fuels. The former would both remove distortionary subsidies on a public bad, alleviate negative effects on climate change and could, in some cases, reduce fiscal deficits. However, it is likely to require carefully designed fiscal measures to compensate low-income consumers, introduced in advance. Furthermore, where profitability of renewables has been damaged by the fall in the cost of fossil fuels, some of the resources could be used both for temporary subsidies on those renewables, and for funding research on reducing costs of renewables in specific country contexts.

It is important to stress here that there is an important literature (for example, Acemoglu et al., 2012), which argues that without public intervention, for example through funding research on innovation in clean energy, the economy would rapidly head towards an environmental disaster, particularly because the market size effect and the initial productivity advantage of fossil fuel inputs would direct innovation and production to that sector, contributing to environmental degradation. However, policies such as using taxes or even politically simpler, cuts in subsidies, could be used to redirect technical change and avoid environmental disaster. Naturally, for countries not extensively using fossil fuel subsidies, they could increase taxes on fossil fuels.

Both as regards supporting technological innovation for renewables and for providing cheaper finance for those renewables, public development banks can play a very valuable role. Furthermore, public development banks can evaluate all projects, but especially energy ones, by including a shadow price of carbon in the project evaluation (as for example the European Investment Bank does, and the German KfW), which implies they are more likely to approve funding for projects with lower carbon emissions.

More broadly, as discussed in more detail in section III, policies of taxes and subsidies on fossil fuels need to be counter-cyclical and linked to the level of oil prices. Thus when the price of the particular fossil fuel fell - which is the most important competitor of renewables in the specific country - taxes on them could rise, and/or subsidies on them be lowered. As pointed out, the resources could be used to subsidize renewables, and/or research in them, as well as to compensate poor consumers that may be hurt by those measures. When the price of the fossil fuel would rise, taxes on them could be lowered. A very attractive feature of this counter-cyclical mechanism, especially for governments, is that it would fund itself and not require additional fiscal expenditure.

As discussed in section III, such policies would need to be adopted at a national level, and be suitably adapted to national circumstances. However, they should be coordinated regionally and internationally, with an important role for the UN and for regional and multilateral development banks.

This important policy area seems to require further research. One possible field of investigation is to conduct interviews with private investors in renewables in different countries to understand their individual cost structures and the possible need for them to receive subsidies, under different levels of prices of fossil fuel and other circumstances. A second field of research is to study in-depth policy options in different LAC countries, to successfully implement the type of policies discussed here, in ways suitably adapted to their country circumstances.

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Annex

Annex 1

Table A.1
Electricity production from oil sources[a]
(Percentage)

Region	Electricity production total
World	4.1
North America	0.8
Sub-Saharan Africa	3.2
European Union	2.2
East Asia & Pacific	2.8
South Asia	5.4
Middle East & North Africa	24.2
Latin America & Caribbean	11.2
Europe & Central Asia	1.9
Central Europe and the Baltics	1.0
Arab World	23.3

Source: from World Bank database: World Development Indicators.
[a] Sources of electricity refer to the inputs used to generate electricity. Oil refers to crude oil and petroleum products.

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