Renewable Energy Policies: Work in Progress

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The Abdullah Bin Hamad Al-Attiyah International Foundation for
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INTRODUCTION

RENEWABLE ENERGY POLICIES: WORK IN PROGRESS

Policies to encourage renewable energy have increased steadily since the late 1990s, and particularly after the 2015 Paris Agreement on climate change.

These have reduced the cost of renewables, encouraging widespread adoption. Which policies are countries adopting to boost the competitiveness and deployment of renewable energy? What drives them to do so? What are the evolving trends in new or reshaped policy? And what can fossil fuel exporters do in the field of renewable policy?

THE ABDULLAH BIN HAMAD AL ATTIYAH FOUNDATION

Sustainability Report

This research paper is part of a 12-month series published by the Al-Attiyah Foundation every year. Each in-depth research paper focuses on a prevalent sustainable development topic that is of interest to the Foundation's members and partners. The 12 technical papers are distributed to members, partners and universities, as well as made available online to all Foundation members.

EXECUTIVE SUMMARY

- Countries have been adopting multiple policies to support renewable energy, driven by the objective to limit climate change and meet their obligations under the Kyoto (1997) and Paris (2016) Agreements.
- Limiting global warming to a maximum 1.5°C will require greenhouse gas (GHG) emissions to fall by 7.6% per year till 2030. Depending on the scenario, renewables will likely have to grow by 50-90% by 2050, and non-hydro/biomass by a factor 2-10 times.
- Although there is an uptake in renewables, energy efficiency and energy access are growing rapidly, the world is not on track to meet the Paris Agreement or the Sustainable Development Goal 7 (SDG7 targets).
- Renewables policies can be divided into supporting a) R&D; b) deployment; c) integration; and d) decarbonisation.
- A consistent, coherent and context-specific mix of renewable energy policies proves more effective in boosting renewable energy in the energy mix.
- Despite the remarkable progress observed in the power generation sector, extensive policy efforts are needed to encourage incremental research and development as well as breakthroughs, from early-stage research to commercialisation.
- Renewable energy policies continue to focus on the power sector, while far less growth has taken place in the cooling, heating and transport sectors.
- Although the initial purpose of these policies was to reduce GHG emissions, many countries now adopt them for their perceived socio-economic benefits. But optimising this may require somewhat different policies.
- The recent success in growing the size and reducing the cost of renewables now requires new policies on grid integration, long-term storage, electricity market design, international cooperation and non-electric renewables.

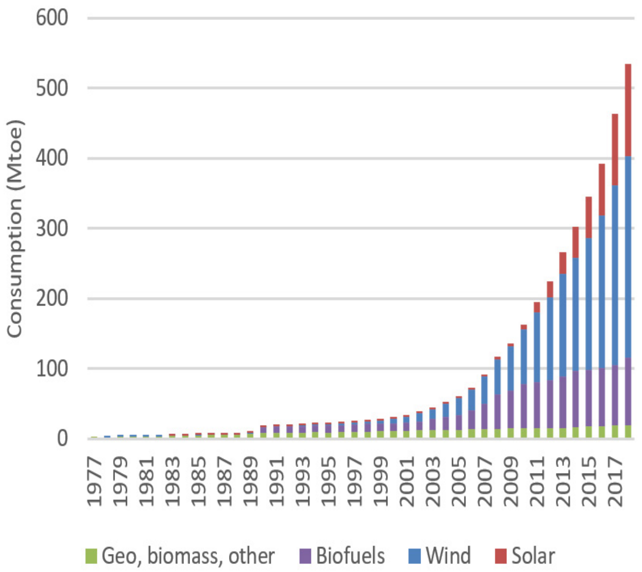
RENEWABLES HAVE BECOME ESTABLISHED AS THE SINGLE LARGEST COMPONENT OF LIMITING CLIMATE CHANGE

Interest in renewable energy promotion dates back to the oil crises of the 1970s, particularly associated with US incentives for solar and wind development.

As FIGURE 1 shows development of renewables started from a very low base during the 1970s. The compound annual growth rate of the non-hydro, non-biofuel renewables was 11.3% during the 1980s, slowed to 7.6% in the 1990s, before accelerating to 17.9% in the 2000s and 20.3% in the 2010-18 period. The group of geothermal + biomass (this excludes 'traditional' biomass) dominated initially, but was overtaken by wind in 2002, and by solar in 2012.

The role of renewables in different scenarios for meeting the 2016 Paris Agreement's aspiration of limiting global warming to no more than

FIGURE 1 HISTORIC RENEWABLES OUTPUT (BIOFUEL DATA NOT AVAILABLE BEFORE 1990)[i]



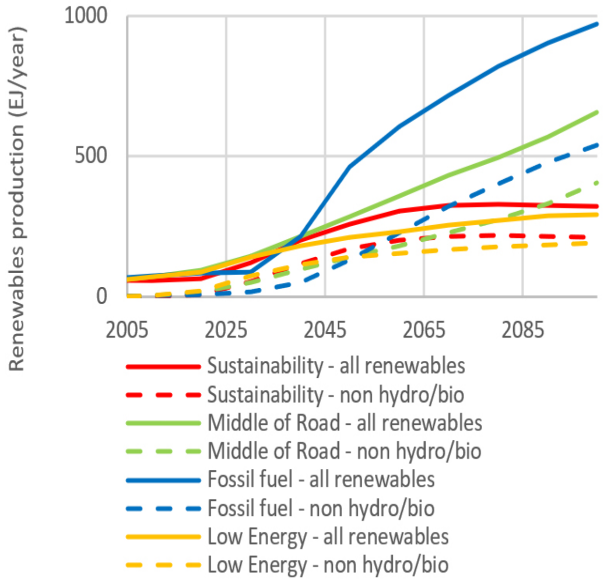
1.5°C is shown in FIGURE 2. A wide range of future energy systems are in principle compatible with this goal. Four are shown here: Low Energy (relies on energy efficiency and productivity), Sustainability (a broad focus on low-carbon), Middle of the Road (historical patterns with improvements in energy production), and Fossil Fuel (high continuing use of fossil fuels counterbalanced by carbon capture and storage (CCS)). Renewable production is shown for all renewables, and (dashed lines) for the 'new renewables' subset excluding hydropower and biomass (i.e. mostly solar and wind, and some geothermal).

All the scenarios have an enormous ramp-up in renewables: from about 70 exajoules (EJ) today, to 209-463 EJ annually by 2050. However, over this long period, this does not reflect particularly high growth rates: 5.9% annually in the highest case, with the 'new' renewables at 10.2% per year.

The renewable share of primary energy in these scenarios also rises sharply, and the range between share in the various scenarios is less

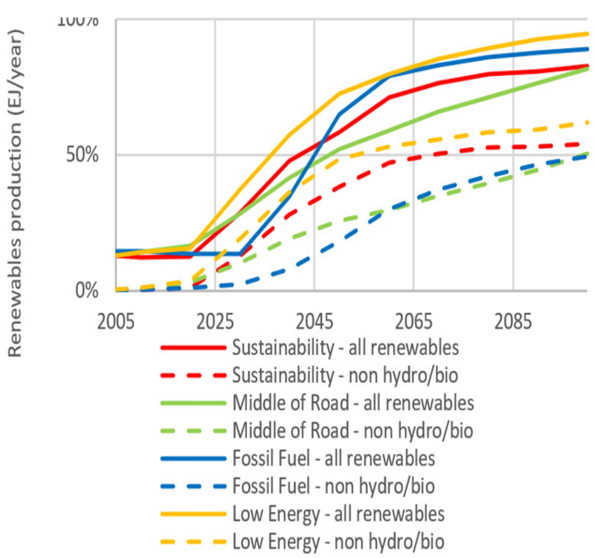
RENEWABLES: THE SINGLE LARGES COMPONENT OF LIMITING CLIMATE CHANGE

FIGURE 2 RENEWABLES IN DIFFERENT IPCC 1.5 DEGREE SCENARIOS [ii]



than for the absolute output (FIGURE 3). The share of renewables by 2050 is 52-72%, and that of the 'new renewables' 18-48%. Even in the 'Fossil Fuel' scenario, the total renewable share in 2050 is 65%, though it has a slower take-off. But all scenarios concur that renewables adoption should be particularly rapid in the 2020-2040 period, over which current policies are likely to be influential.

FIGURE 3 PROJECTED SHARE OF RENEWABLES IN DIFFERENT IPCC 1.5 DEGREE SCENARIOS [iii]



COUNTRIES HAVE ADOPTED NUMEROUS RENEWABLE POLICIES

Modern deployment of renewable energy has been driven primarily by countries' aim to limit climate change, and to meet their commitments to reduce greenhouse gases in the 1992 United Nations Framework Convention on Climate Change (UNFCCC), 1997 Kyoto Protocol and 2016 Paris Agreements. This has been encouraged and, in many cases, initiated by pressure from environmental advocacy and civil society groups.

The Kyoto Protocol contributed in a modest way to the growth of renewable energy sources, particularly in the EU, and in countries like China and India, that participated actively in the Clean Development Mechanisms (CDM).

"In 2007, everyone was still saying that generating 20% of energy in Europe from renewables in 2020 would be utopian. Today it is reality...Kyoto is not solely responsible for investments in the energy transition, but it was an important stimulus," said Karsten Neuhoff, head of climate policy at the German Institute for Economic Research[iv].

The European Union (EU) has had the strongest multinational renewable policies. In response to the Kyoto Protocol and its climate obligations, the 2009 Renewable Energy Directive set a target of 20% of total energy from renewables by 2020, made up of distinct national targets, and 10% of transport fuels to be renewable by that date[v]. The revised 2018 renewable energy directive sets a target of 32% renewables by 2030, with scope for an upwards revision by 2023.

In 2009, the International Renewable Energy Agency (IRENA) was established, as an intergovernmental organisation intended to promote the transition towards renewable energy worldwide.

The UN Sustainable Development Goals were agreed by 193 countries in 2015. The key energy-related provisions, all relevant to renewable energy, were[vi]:

- Deliver universal access to modern energy by 2030
- "Increase substantially" the share of renewables in the global energy mix by 2030
- Double the rate of energy efficiency improvement by 2030
- Enhance internal cooperation on renewables, energy efficiency and cleaner fossil fuels
- Ensure success of the Paris Agreement, limiting global temperature rises to "well below 2°C", an ambition later tightened to below 1.5°C
- Reduce deaths due to air pollution

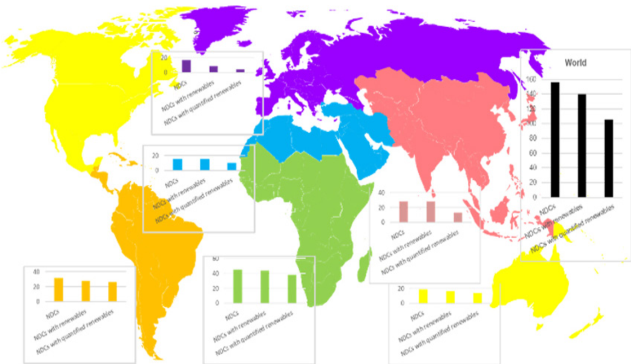
The Paris Agreement was required to replace the Kyoto Protocol, whose second commitment period ran to 2020.

As a key part of the Paris Agreement, signatories submitted Nationally Determined Contributions [vii], laying out voluntary commitments to achieve their part of the 1.5°C goal, typically including elements such as increasing the use of renewable energy, alongside improving efficiency, using other low-carbon power including nuclear and carbon capture and storage (CCS), encouraging electric vehicles and public transport, reducing other greenhouse gas (GHG) emissions such as gas flaring and methane, and reducing land-use emissions.

However, the current NDCs on aggregate fall well short of the 1.5°C target (they are estimated to equate to warming of about 2.6°C), and they do not even include all existing national targets and policies, nor reflect current growth rates. The International Renewable Energy Agency (IRENA) found that:

- 135 countries have domestic renewable targets
- But only 85 included these unconditionally in their NDCs.
- 140 NDCs mention renewables, but only 105 of them quantify targets.
- NDCs imply renewables growth of 4% per year during 2015-2030, while actual growth rates since 2015 have been 8.6% annually[viii] .

FIGURE 4 RENEWABLES IN THE NDCS, BY REGION[ix]



At COP26 in Glasgow, originally scheduled for November 2020, parties were expected to increase the ambitions of their NDCs. This event has now been postponed because of the coronavirus pandemic, but there will still be an expectation of more stringent NDCs, including stronger renewables policies. By then, the US presidential election will have concluded, giving indications on whether the US will rejoin the Paris Agreement and therefore the NDC process.

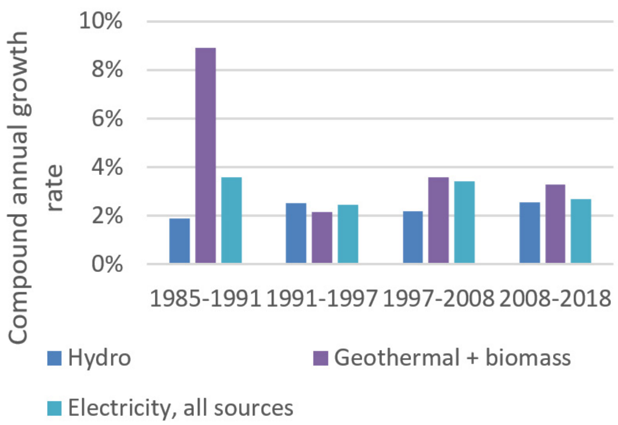
Case Study Germany

- Germany was an early pioneer in renewables, with its 'Energiewende' (energy transition). Initially, renewables were given feed-in tariffs and priority grid access, that guaranteed attractive returns. This became increasingly expensive, and from 2017 large projects have been awarded by auction.
- This has enjoyed broad legislative support from both left- and centre-right parties.
- The goals are not just decarbonisation, but the replacement of nuclear, and the 'democratisation' and decentralisation of energy production.
- Renewables generation in 1990 was 18.9 TWh, 3.4% of the total, of which hydro was 3.1%. By 2018, renewables generation was 226 TWh, 37.8% of the total, of which hydro was 2.8%. Onshore wind, solar PV, biomass and offshore wind, in descending order, were the most important. The government aim is to reach 65% electricity from renewables by 2030.
- Germany was a market leader in solar PV manufacturing, but this has almost entirely ceased, though it still makes components such as inverters. However, it remains a leader in wind power manufacturing via companies such as Siemens.
- However, the cost has given Germany the highest power prices in Europe. The climate is not very favourable for solar PV despite the huge installation. Insufficient transmission capacity from wind power in the north to demand centres in the south has been a problem, with public opposition to new lines.
- Onshore wind has faced growing public opposition and lack of land. Biomass makes up 7% of electricity generation but contributes to air pollution.
- Decarbonisation has been less successful than renewables deployment, because of the shutdown of nuclear, requiring continuing use of coal.
- Overall, the major contributions of German renewables policy has been to establish approaches (feed-in tariffs) that were widely adopted elsewhere; and to bring down the cost of solar and wind for others via mass deployment.

RENEWABLES GROWTH FROM 1997 TO THE PRESENT HAS BEEN VERY STRONG

As FIGURE 5 shows, the growth rate of "established" renewables (where technology has been relatively mature since the 1980s – hydro, geothermal and biomass) has been moderate. The periods shown encompass the pre-UNFCCC, the UNFCCC-Kyoto, Kyoto to the global financial crisis (GFC), and the post-GFC. Hydro through this period grew more slowly than world electricity from all sources (including fossil fuels and nuclear). Geothermal + biomass grew fast in 1985-1991 but slowed down thereafter.

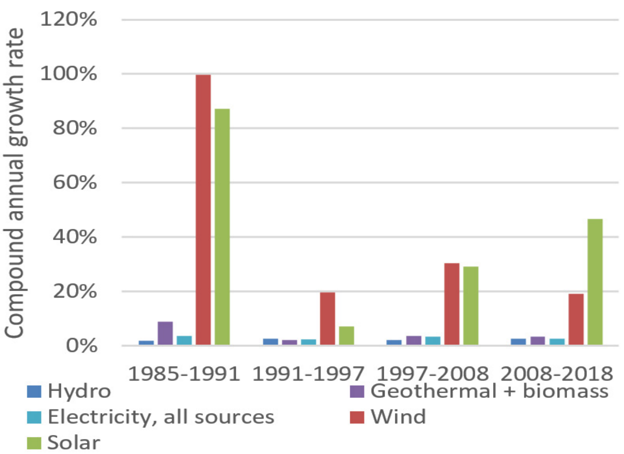
FIGURE 5 GROWTH RATE OF GENERATION FROM ESTABLISHED RENEWABLES[x]



The picture is different, though, when including the "modern" renewables, wind and solar (FIGURE 6). They grew at very rapid rates pre-1991, albeit this was for immature technologies growing from a very small base. Growth slowed in the 1991-97 period but accelerated after Kyoto. Although after the GFC, wind's growth slowed to 19% annually, this is impressive for a maturing technology with an increasingly large installed base. And solar power's growth actually accelerated after the GFC, as it became increasingly economically competitive.

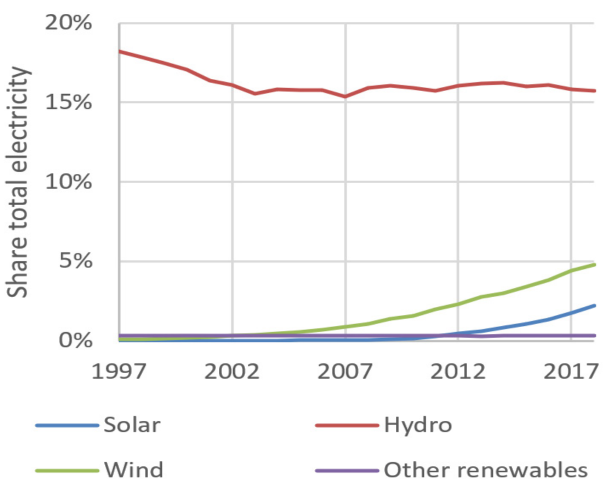
RENEWABLES GROWTH FROM 1997 TO THE PRESENT HAS BEEN VERY STRONG

FIGURE 6 GROWTH RATE OF GENERATION FROM RENEWABLES[xi]



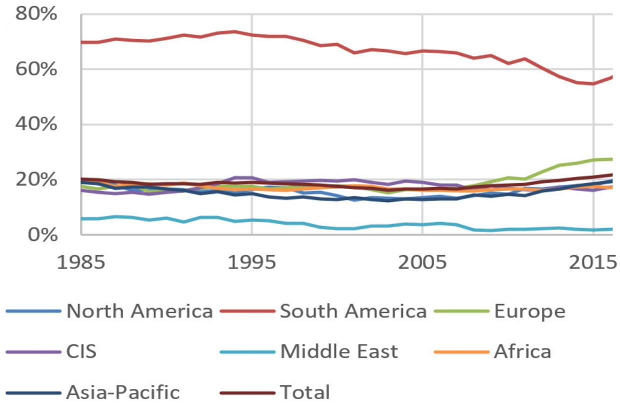
In the period since Kyoto, the share of hydroelectricity in total world electricity fell before stabilising, mainly due to dam construction in China. The share of geothermal remained small and stable. But the share of wind, then solar, has risen rapidly, albeit remaining relatively small.

FIGURE 7 SHARE OF RENEWABLES IN WORLD ELECTRICITY[xii]



From a regional point of view (FIGURE 8), two regions stand out.

FIGURE 8 SHARE OF ELECTRICITY FROM RENEWABLES, BY REGION[xiii]



South America has a very high renewables share because of a large use of hydropower (and to some extent biomass); however, this has dipped as large hydro sites have increasingly been developed, and in some cases affected by drought. Since 2013, the rapid growth of wind in Brazil and solar in Brazil and Chile has helped the share rise again.

The Middle East, conversely, stands out for a very low renewable share, mostly because of its lack of hydroelectric resources which have historically formed the bulk of renewable generation.

In the middle of the pack, with about 20% renewable share, are all other world regions. Europe has recently increased beyond this because of solar and wind. Africa's low share is surprising and a sharp contrast to South America, given its huge hydroelectric resources in relation to relatively small demand. The world share of renewables remained very stable at 17-20% during 1985-2008, but since the GFC it has begun to climb to reach 23% by 2018.

The picture is different, though, when considering only the 'new' renewables, solar and wind (FIGURE 9, shown from 1995 onwards since the share before Kyoto was negligible).

FIGURE 9 SHARE OF ELECTRICITY FROM 'NEW' RENEWABLES, BY REGION[xiv]

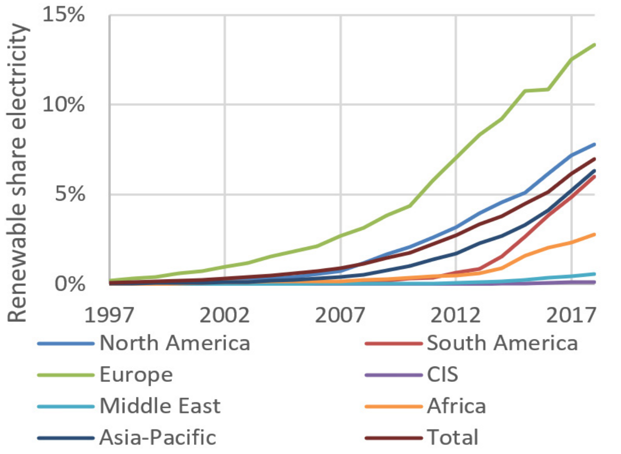
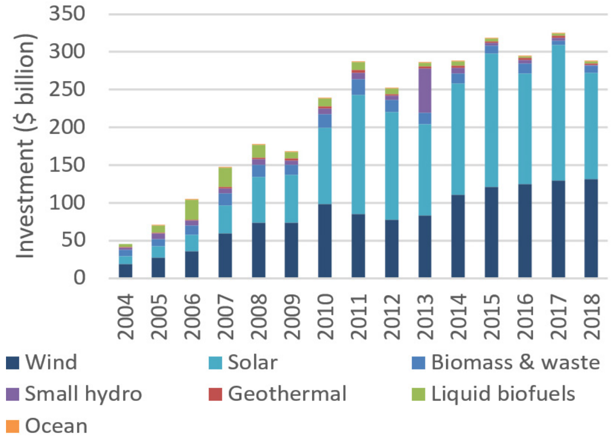


FIGURE 10 INVESTMENT IN RENEWABLES (EXCLUDING LARGE HYDRO)[xv]



This shows Europe clearly taking the lead, in pursuit of its target of 20% of all energy from renewables by 2020. As a coherent bloc, it is not surprising that it was able to make quicker progress than other regions which contain a mix of leaders and laggards.

North America and Asia-Pacific made steady but slower progress. It is notable that the shale gas boom in North America did not appear to deter renewable installation. The advance in Asia-Pacific is dominated by three giants, China, India and Japan, which may obscure trends in other countries.

South America did little until 2013, but accelerated rapidly thereafter, led as noted above by Brazilian solar and wind, and Chilean solar. Africa tracked South America until 2013 but has somewhat stagnated since then. South Africa, Morocco and Egypt have been the relative leaders.

Finally, the Commonwealth of Independent States (CIS, approximating the former Soviet Union, FSU) and Middle East have very low renewable shares. This chart does not show the recent surge in solar installation in the Middle East, which should raise this share in the near future. The low share of these two regions may reflect the dominance of fossil fuels in the energy mix, as both have attractive renewable resources.

This rise in renewables has been facilitated by heavy investment (FIGURE 10), running at about $300 billion annually from 2011-18.

However, after rising rapidly up to 2011, renewables investment has relatively stagnated since then. Costs have fallen; therefore the same investment can now procure a larger quantity of renewables. But the investment levels are still inadequate to meet the Paris goals and other targets.

Nearly all current investment is going into wind and solar. This reflects their greatly improved cost competitiveness and performance, but it does suggest a relative neglect of other important technologies, including those that provide dispatchable power such as biomass, geothermal and small hydro; and those used in transport (biofuels). Notably, since 2012, the fall in oil prices and the growth of concerns about the environmental impact of biofuels has seen investments in them nearly dry up.

A WIDE RANGE OF POLICY INSTRUMENTS EXIST

Pro-renewables policies can be classified in different ways:

- Voluntary and informational (targets, aspirations, roadmaps, personal/corporate procurement) versus mandatory
- By objective: research and development (R&D); deployment; supporting technology (grids, batteries and so on); decarbonisation
- By type

TABLE 1 MAIN RENEWABLE POLICIES AND AIMS

Policy type	Effect	Primary focus
Targets, roadmaps	Encourage deployment and help planning	All
Information, removing institutional barriers	Lower cost and raise ease of deployment	Deployment
R&D subsidies, government-funded research, prizes	Increase return on R&D investment, as private sector underinvests in research due to time horizons, risk aversion, inability to capture spillovers	R&D
Direct deployment subsidies (cash / low-cost finance, land, tax credits, etc)	Ensure private deployment by lowering effective cost	Deployment
Feed-in tariffs and premia	Raise returns for private deployment	Deployment
Direct procurement / auctionsi	Ensure deployment of a defined quantity at lowest cost	Deployment (supporting tech in case of storage procurement)
Training, certification	Lower cost and raise ease of deployment	Deployment
Net metering	Raise returns for private deployment by compensating non-self use	Deployment
Priority grid access	Improve renewable utilisation factors	Deployment, (supporting tech)
Renewable portfolio standards (can be tradable)	Mandate a level of renewables	Deployment
Compulsory retirement of non-renewables	Create market space for renewable deployment; reduce 'lock-in' of high-carbon assets	Deployment
Carbon taxes, carbon trading, portfolio emissions standards	Encourage low-carbon energy sources	Decarbonisation

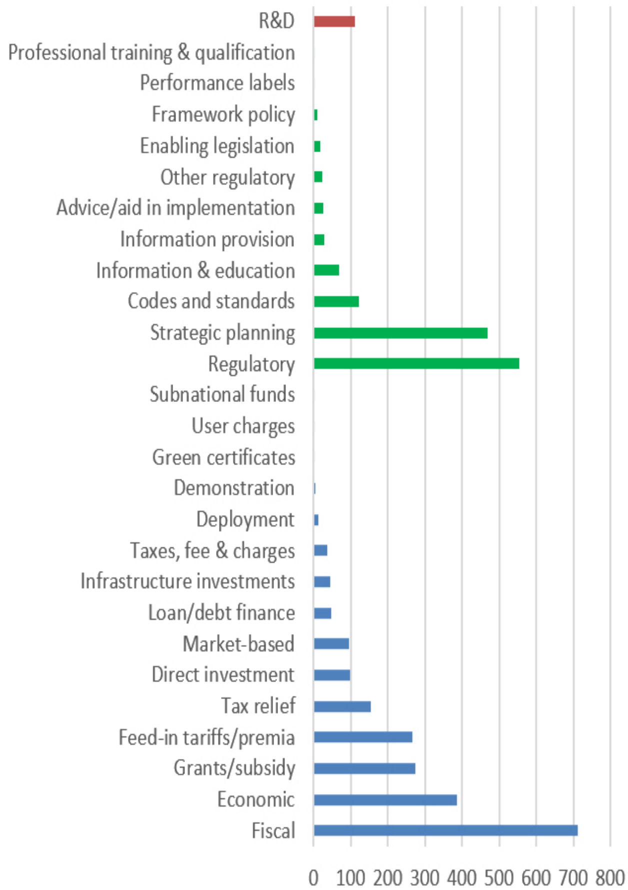
Certain types of policy are best suited to certain objectives. For instance, a carbon tax promotes decarbonisation, and that may be via renewables, nuclear, energy efficiency or other approaches. Others act through several objectives. For instance, a renewables mandate for electricity supply promotes deployment, but it also encourages R&D (to provide better and lower-cost renewables), supporting technologies (to integrate those new renewables), and decarbonisation.

Policies can also be technology-specific or technology-agnostic. Feed-in tariffs have typically been set at different levels for different technologies, reflecting varying levels of cost and maturity. Direct auctions for capacity have typically been for specific technologies but could also be for capacity of any type. However, this does raise the difficulty of comparing renewables with different levels of dispatchability and diurnal/seasonal patterns. This can be dealt with by bids for firm capacity, secured either with storage or dispatchable backup generation. Carbon-based policies represent the broadest technology-agnostic approach, since they place renewables on a level playing field with other low-carbon technologies.

But other policies can be redundant or even act at cross-purposes. For instance, a tradable cap on carbon emissions that is less stringent than a renewables mandate will simply result in very low emissions prices, as the renewables mandate already delivers the emissions reductions. This was the fate of the European Emissions Trading System (ETS) for significant periods of its operation. Subsidies for renewables deployment when renewables are already the lowest-cost form of generation will allow developers to make extra profits without delivering any more capacity.

FIGURE 11 groups global policies into those which are economic and financial; regulatory, informational and strategic; and R&D-based. Overall, 3575 policies were identified by type, region and technology (some policies may occur in more than one category; hence the total number of existing policies is less). Note this does not include vehicle- or building-centric policies, and it only counts active policies, not those which have expired. Overall, 2141 economic policies, 1322 regulatory ones, and 112 R&D-based, were noted. There is a clear worldwide preference for regulatory and strategic planning measures; and fiscal, economic, subsidy/feed-in tariff and tax-based support. Direct investment, demonstration and deployment policies have been much less-used, as has professional training and labelling.

FIGURE 11 GLOBAL RENEWABLE POLICIES BY NUMBER[xvii]



A WIDE RANGE OF POLICY INSTRUMENTS EXIST

By technology, policies have favoured renewables in general, then solar, then wind, with hydro and geothermal less favoured. Solar support has concentrated more on economic measures, while wind a little more towards regulatory. Most R&D policies focus on renewables in general.

FIGURE 12 NUMBER OF WORLD RENEWABLES POLICIES BY TECHNOLOGY[xviii]

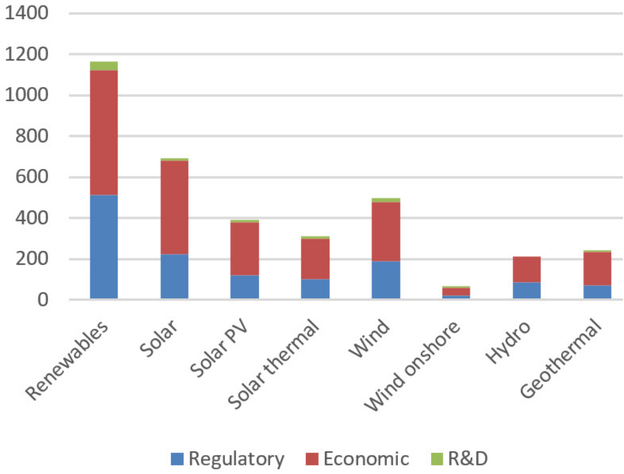
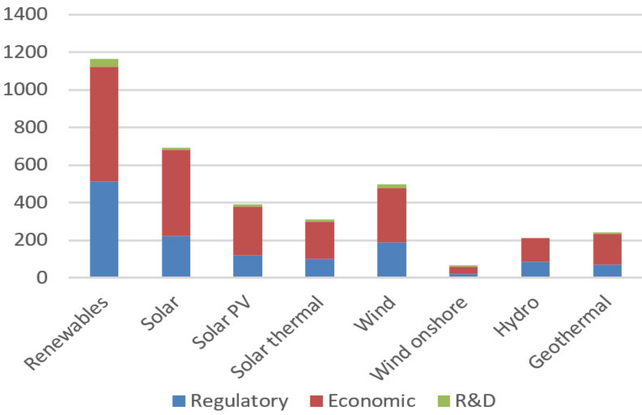


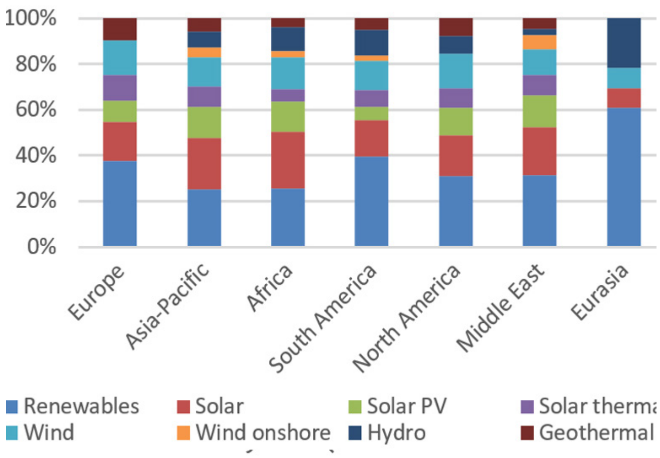
FIGURE 13 RENEWABLE POLICIES BY REGION[xix]



By region, Europe is not surprisingly the leader in the total number of policies (FIGURE 13). Europe, Asia-Pacific, Africa, South America and North America each have roughly similar numbers of regulatory-based policies, but Europe (and to a lesser extent, Asia-Pacific) stand out for the large number of economic/financial policies. Europe also has the largest number of R&D-based policies. The Middle East and Eurasia are notable for the very low number of renewables policies.

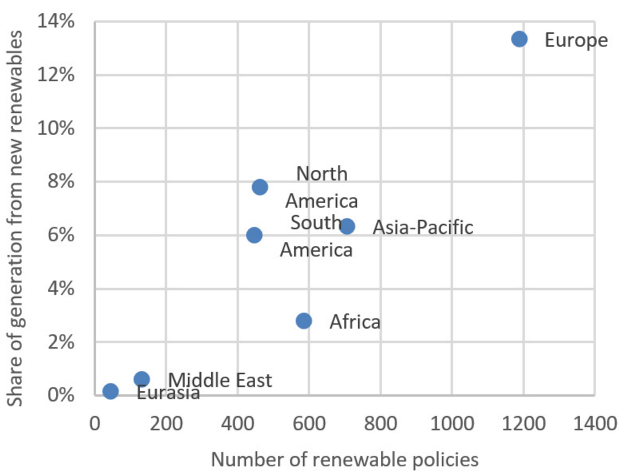
On a regional basis, there is not a big difference in the policy support for technologies (FIGURE 14), except for Eurasia where the limited number of policies are mostly general, and there is also more focus on hydro.

FIGURE 14 SHARE OF RENEWABLE POLICIES BY TECHNOLOGY[xx]



The number of policies also correlates quite closely with the share of 'new' renewables in total generation (FIGURE 15). Africa stands out for having many policies but a low renewable share, while the Americas are vice-versa. This may indicate ineffective or only recently introduced policies in Africa, but it may also be an artefact of the larger number of countries there than in the Americas. Of course, this chart does not prove that the renewables policies are effective; the two variables may simply share an underlying driver, such as political will and public opinion.

FIGURE 15 CORRELATION OF RENEWABLES SHARE AND NUMBER OF POLICIES[xxi]



Case Study China

- China has deployed all renewables on a huge scale: 326 GW of hydro, 205 GW of onshore wind, 6 GW of offshore wind, 205 GW of solar PV, 10 GW of bioenergy, 6 GW of renewable waste and 0.4 GW of solar thermal.
- Nevertheless, the share of renewables including hydro has hardly moved since 1985 from about 22-25%; wind is 5.1% of generation and solar 2.5%.
- Non-hydro renewables deployment in China has been driven by feed-in tariffs set by central government and adjusted at intervals. These have promoted rapid growth but did not encourage cost reductions. From 2019, auctions have been preferred and reduced costs 30% for utility-scale solar below 2018 levels. More than 20 GW of unsubsidised renewables projects were approved in 2019. In May 2019, a renewable portfolio standard was released, differentiated by province.
- Curtailment of remote inland wind resources has reduced. But renewables still face challenges competing against cheap coal.
- China has become the world leader in manufacturing many renewable technologies, particular solar PV panels and also wind turbines and batteries. However, its renewable manufacturing policy has been much more successful than its domestic renewable deployment policy, and the two have been rather separate rather than coordinated.
- China's Belt and Road Initiative (BRI), intended to invest in Eurasia, south-east Asia and the Middle East, has focussed almost entirely on coal and large hydro rather than other renewables.

As noted, deployment of renewables has historically been primarily driven by attempts to meet climate change and emissions reductions goals. Renewables overall have very low greenhouse gas emissions in operation (geothermal and hydroelectric release some carbon dioxide and/or methane), and relatively low life-cycle footprints when including the energy and material input to construct them.

Renewables have been seen to have other environmental advantages, notably lower air and water pollution. They are seen as safer than nuclear and fossil fuel; although it is true they are less prone to disastrous large-scale accidents, the rate of death and accident during construction may sometimes be higher than competing technologies.

However, these have not been the only drivers. Historically, early interest in 'modern' renewables in the 1970s was driven by the oil shocks of 1973-4 and 1979-81. High energy prices and fears of 'running out' of oil drove a search for alternatives. Nuclear power was widely adopted, particularly in countries such as France, the US and Sweden, but lost popularity in the 1980s as a result of escalating costs and concerns over safety and contamination, after the accidents at Three Mile Island (1979) and Chernobyl (1986).

These concerns over fossil fuel availability and nuclear reliability surfaced again in the early 2000s, with escalating oil and gas prices, fears of 'peak oil' supply[xxii], and the 2011 Fukushima nuclear accident in Japan. Renewables were seen to be an inexhaustible energy source that offered long-term stable and predictable pricing, even if initially more expensive than fossil fuels. Indeed, the name 'renewables' draws attention to their non-depleting aspect, rather than their low-carbon or environmentally-friendly features, even though some 'renewables' (such as geothermal), can deplete locally.

Related to these concerns over energy prices are issues of energy security, self-sufficiency and diversification of supply. After repeated cut-offs of supplies of Egyptian gas because of pipeline sabotage, left it dependent on costly fuel oil and diesel, Jordan stepped up its solar and wind power programme. Locally produced renewables are seen as reducing reliance on imported hydrocarbons and reducing the overall price volatility of the energy portfolio.

The creation of new jobs and industries has been another aim of the policy. Renewables generate a significant amount of 'green jobs' during installation/construction, including manual work, where Western countries have been concerned about the loss of employment opportunities. Manufacturing offers skilled employment and export opportunities. Countries such as India, Saudi Arabia and Turkey have set 'local content' requirements[xxiii] , and solar PV has been an important part of the 'Make in India' strategy. In practice, though, despite initial leads in Germany, Denmark, the US and Canada, China has increasingly come to dominate manufacturing of solar, wind and battery equipment. Indeed, China's renewable energy strategy has concentrated more on manufacturing than on deployment at home, and these two areas have been rather separate in policy[xxiv].

Renewables have also been seen as a way of creating community ownership and buy-in, decentralising and democratising energy. The idea of reducing dependence on large corporations has political appeal for many. For instance, community wind farms allow local individuals, businesses and cooperatives to invest collectively[xxv]. This has been part of the appeal for rooftop solar in Germany. The idea of individual homes going completely 'off-grid', relying on solar or wind with batteries[xxvi], has gained popularity. However, the increasing sophistication and economies of scale for giant solar arrays and offshore wind farms may limit this trend.

In areas lacking modern energy access (electricity and cooking fuels), particularly sub-Saharan Africa, small-scale renewables (solar, wind, biomass and run-of-river hydro) have been seen as options to power local microgrids or minigrids, instead of relying on non-existent or unreliable national grids. For remote sites – mines, military bases, border posts, telecommunications towers, water pumps and so on – local renewables can also be cheaper and less logistically vulnerable and complicated than bringing in diesel to run generators or installing long-distance electricity cables.

RENEWABLE POLICY HAS ENCOUNTERED VARIOUS CHALLENGES AND UNINTENDED CONSEQUENCES

The main failing of renewables policy so far is that, despite great attention, heavy investments and the urgency of the task, deployment is still too low to meet climate goals

As TABLE 2 shows, even the recent post-GFC accelerated rate of renewables deployment is a factor 4-12 times too slow to meet the 2050 goals. This is even more so when considering that recent hydroelectric deployment rates can probably not be sustained because of a lack of suitable sites and the associated environmental damage, so solar and wind will likely have to provide most of the required capacity

TABLE 2 HISTORIC AND REQUIRED RENEWABLE DEPLOYMENT RATES [xxvii]

Time period	All renewables growth, EJ/year	Modern renewables growth, EJ/year
2020-50	4.6-13.1	
1997-2018	0.67	0.4
2009-2018	1.1	0.7

This is not necessarily a criticism of past renewables policies; just a recognition that they have not been adopted in the scale and speed required.

Part of this comes from a lack of adequate attention to the problem of climate change, particularly in some developed countries.

As renewable costs have fallen, older contracts signed at higher prices have become unaffordable. In 2010-11, Spain cut subsidies for both new and existing plants, drawing complaints from investors[xxviii]. Germany cut its solar subsidies in 2012, and UK installations of home solar panels dropped 94% in 2019 when subsidies were reduced[xxix]. Retroactive changes can undermine market confidence in the sector.

Very high subsidies for early generations of renewables have led to a burden on consumers, notably a problem in Germany through renewable levies on electricity bills. However, the sharp recent falls in renewables costs, to the level where they are often cheaper than conventional power, should prevent this problem in future.

Higher shares of renewables can cause concerns about grid stability and sufficient levels of back-up. However, in practice, countries' grids have generally proved able to operate with high levels of variable renewables. A variety of options exist for integrating high shares, up to around 80%[xxx].

Despite their low-carbon nature, renewables are not entirely environmentally benign. In particular, large hydro causes habitat loss, destruction of cultural sites, and methane emissions from periodically flooded areas. Dams can be vulnerable to failure, for instance from poor design or earthquakes, threatening downstream populations.

Biomass/biofuels are problematic because they put more stress on land use. Even if they are not grown specifically on deforested land, they can drive up food prices and push cultivation into virgin forests.

The availability of raw materials for various renewable technologies, such as rare earth metals for magnets in wind turbines, tellurium in some solar panels, and lithium, cobalt, nickel and graphite in batteries, has raised some concerns. China is particularly dominant in some minerals, such as the rare earths, and there are concerns by some that China might try to use these geopolitically, even if such attempts are likely to fail in the longer term. Finally, mining of some materials, particularly the rare earths, is environmentally destructive and polluting. The Democratic Republic of Congo, with most of the world's current cobalt production, suffers environmental degradation and labour abuses.

RENEWABLE POLICYMAKING IS DEVELOPING IN RESPONSE TO EXPERIENCE AND EMERGING CHALLENGES

Renewable energy policy has evolved in response to more than two decades of extensive experience, emerging challenges, and the much greater size and competitiveness of the industry.

More policymakers stress a tailor-made approach that reflects the local market, institutional and administrative capacity and the unique political, economic and social conditions of the regional, sub-national or national energy systems in which the policies are to be applied.

Policy sequencing is central for the effectiveness of renewable energy mechanisms, which entails the existence of basic regulatory preconditions along with robust institutional and administrative efficiency. Renewable energy installations can be scaled up from initial pilots to allow learning, iron out regulatory and incentive schemes, and test grid integration, with larger projects coming later to reduce costs.

The move to auction-based renewables awards has put much more emphasis on reducing costs than the previous feed-in tariff/fixed-price schemes[xxxi]. A consistent pipeline of new projects allows developers to continue expanding and innovating. As the scale of required renewables grows, it becomes increasingly important to drive down costs to avoid too much burden on taxpayers or consumers.

Government pre-investment can help reduce costs. For instance, in the Netherlands, the government mapped out offshore wind locations to give certainty to developers and avoid duplication of surveying efforts. This has enabled it to award several large projects via auction without subsidies[xxxii].

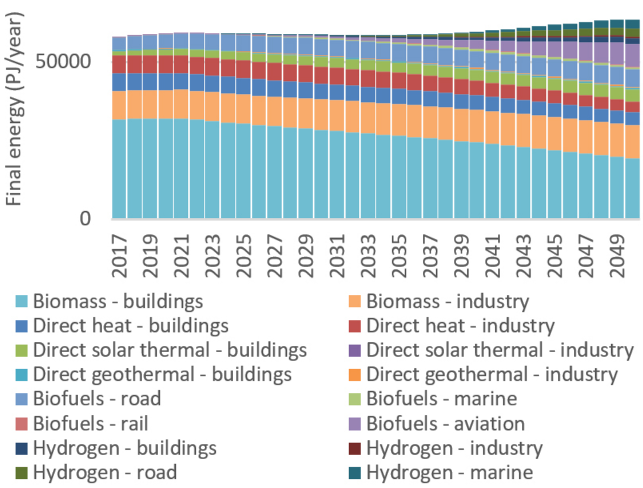
TRANSPORT, DESALINATION & HEATING/COOLING HAVE BEEN LEFT BEHIND

Most renewable policy to date has focused on electricity generation. To the extent renewables are considered for other sectors (heating/cooling, transport and industry), a large part of this is assumed to be achieved by electrification, including electric vehicles.

However, some sectors are economically or technically difficult to electrify. Electric home heating implies very large loads at times during winter, currently supplied in North America, Europe, Russia and north-east Asia primarily by natural gas. Long-distance road, sea and air travel is difficult to meet even with improvements in batteries' weight and cost.

FIGURE 16 presents one outlook for renewables outside the electricity sector. While the total quantity is roughly flat to 2050, the composition changes significantly. Biomass use in buildings and industry (mostly traditional biomass) declines, and road biofuels grow only moderately, but the aviation sector becomes a major biofuel user, of the same scale as road. Hydrogen also becomes an important energy carrier for road, marine and buildings. Alternative views might see a larger role for hydrogen in aviation.

FIGURE 16 OUTLOOK FOR NON-ELECTRIC RENEWABLES, 2017-50[xxxiii]



Probably the largest set of renewables policies outside the electricity sector is related to biofuels. Brazil was a pioneer of biofuels, to benefit its sugarcane industry and improve energy security. Ethanol blending was mandatory in 1931, and pure ethanol has been used since 1975. In 2011, 11.8% of the country's total cultivated area was used for biofuels[xxxiv].

In 2005, the US introduced the Renewable Fuels Standard (RFS), mandating blending of ethanol into gasoline (petrol) and biodiesel into diesel[xxxv]. The original intention would have blended 2.3 million bpd by 2022, about 20% of the then forecast motor fuel consumption. This policy had a mix of objectives. Reducing greenhouse gas emissions was relatively less important; more important were reducing dependence on imported oil, supporting the US farm industry, reducing carbon monoxide pollution, and replacing lead as an octane enhancer.

The Energy Independence and Security Act (EISA) of 2007 expanded the RFS, and introduced a requirement to use growing amounts of 'advanced' biofuels, including those made from cellulose. However, technical progress on producing viable cellulosic biofuels has been limited[xxxvi].

The 2003 EU Renewable Fuels Directive mandated 10% biofuels by 2020. The revised Renewable Energy Directive starting in 2020 has a target of 14% renewables in transport by 2030[xxxvii]. It tries to limit some of the negative environmental effects by capping crop-based biofuels at the 2020 level or 7%, whichever is lower; phasing out palm oil use; and boosting 'advanced' biofuels from 0.2% in 2022 to 3.5% by 2030. However, this level will still have to be increased further, since most engines are rated up to 5% or 10% ethanol (in gasoline) or 7% biodiesel (in diesel).

In 2016, modern direct renewable heating accounted for 8% of global heat demand, and renewable electricity for a further 1.8%. Sources of renewable heat include solar, geothermal, bioenergy (modern and traditional), and heat pumps or direct electric heating fed by renewables. But global renewable heat has increased only 1.8% annually in recent years. Demand for cooling, rising about 4% per year, is met primarily by electricity where the share of renewables is still low. However, adsorption and absorption chillers driven by solar heat do exist[xxxviii] .

POLITICAL AND SOCIAL FACTORS STRONGLY INFLUENCE WHAT RENEWABLES POLICIES ARE ADOPTED AND SUSTAINED

The type of policies that are adopted depends strongly on political and social issues, which vary greatly between countries.

The early phase of renewables development in Europe, particularly Germany, was focused on decentralisation and 'democratisation' of energy supply. It won support particularly from communities, which installed locally-owned wind power, and from wealthier homeowners and farmers who could afford to take advantage of the generous incentives for installing solar panels.

In the US, some states have had an outsized political influence, such as Iowa, whose farm lobby has promoted corn-based ethanol. Mid-West swing states with large wind resources, or those in the south-west with solar, might similarly become advocates for those technologies.

likewise trade relations have also been important. Europe has tended to favour biodiesel imports but has moved away from that more recently because of environmental concerns. In 2013, Europe imposed tariffs on Chinese solar panels to protect the domestic industry but removed these in 2018[xxxix]. China's excess capacity after the 2013 move, caused a sharp drop in panel prices and boosted solar power's competitiveness. In 2018, the Trump administration in the US placed tariffs on Chinese solar panels[xl]. In both cases, domestic lobbying was prominent.

In other countries, such as China and the Middle East, state-directed procurement is more important than individual installation. Here, corporate lobbying has been more important at the government level. Some countries, such as Jordan and Morocco, moved ahead on solar and wind power while others with somewhat similar circumstances, such as Lebanon and Tunisia, did not. This was based partly on how individual entrepreneurs and policy advocates were able to capture the attention of government, and partly on how the government itself was able (or not) to drive forward an ambitious renewables policy.

OIL & GAS PRODUCERS HAVE DIFFERENT EXPERIENCES WITH RENEWABLES

Comparing a number of large economies and prominent oil and gas exporters (TABLE 3) suggests a negative association between oil and gas exports, and the degree of domestic renewable development. This is not surprising, as lower domestic hydrocarbon prices and the absence of energy security fears tends to reduce the policy push for renewables. It also creates domestic fossil fuel lobbies that may oppose renewables policies (as in the US, Canada and Australia, which are also all large coal producers). Let's examine the renewables landscape in a few major oil and gas producers, such as Brazil, Canada, Norway and the Gulf Cooperation Council (GCC).

Brazil was relatively late to develop large oil and gas production, via its deep offshore. By this point, it had already become a major renewables player. As noted above, it started a cane sugar-based ethanol policy very early and expanded it during the 1970s oil crises. In 1984, the very large Itaipu Dam became operational, and hydro continues to make up more than 65% of Brazilian electricity. However, droughts have encouraged efforts to diversify generation. The country introduced net metering for solar, wind and small hydro in 2011, with 1.7 GW of distributed generation, mostly solar, installed by November 2019[xlii]. Auctions have been the main method of procuring large-scale capacity[xliii], with Brazil having excellent resources for solar and, along its long coastline, wind.

Canada is also a large hydro player (59% of generation in 2018). Its geographic differences, federal system and the concentration of oil and gas resources in Alberta (and to a lesser extent, Saskatchewan) mean there are sharp differences in generation mix by province. For instance, Manitoba is 96.8% hydro while Alberta is only 2.5%; Prince Edward Island is

TABLE 3 OIL AND GAS OUTPUT AND RENEWABLES SHARE, SELECTED COUNTRIES[xli]

Country	Production 2018		# Renewable policies	% electricity from renewables	
	Oil, Mbbl/day	Gas, BCM/yr		All	Excl. hydro
Oil exporters					
Saudi Arabia	12.2	112	7	0%	0%
UAE	3.9	65	16	0.7%	0.7%
Qatar	1.9	176	3	0%	0%
Kuwait	3.1	17.5	5	0.1%	0.1%
Iran	4.7	240	19	3.6%	0.1%
Iraq	4.6	13	2	3.1%	0.1%
Russia	11.4	670	40	17.2%	0.1%
Kazakhstan	1.9	24	10	10.3%	0.6%
Brazil	2.7	25	48	83.7%	17.8%
Mexico	2.1	37	112	16.2%	6.4%
Venezuela	1.5	33	4	72.6%	0.01%
Nigeria	2.1	49	23	17.2%	0.1%
Angola	1.5	3	15	71.4%	0%
Algeria	1.5	92	10	1.0%	0.8%
Libya	1.0	10	2	0.02%	0.02%
Norway	1.8	121	57	96.9%	2.7%
US	15.3	832	298	16.8%	10.3%
Canada	5.2	185	500	66.1%	6.9%
Median			***15.5***	***13.3%***	***0.1%***
Oil importers					
China	3.8	162	187	25.8%	8.9%
India	0.9	28	159	16.7%	7.8%
Indonesia	0.8	73	72	11.7%	5.5%
Malaysia	0.7	72.5	16	15.2%	0.9%
Australia	0.4	130	141	17.5%	10.8%
Japan	0	3	83	18.4%	10.7%
South Korea	0	0.3	69	4.2%	3.7%
UK	1.1	41	105	33.3%	31.6%
Germany	0.04	6	152	34.9%	32.2%
Egypt	0.7	59	10	8.5%	1.7%
Ethiopia	0	0	8	99.96%	7.03%
Kenya	0	0	11	78.5%	47.4%
Morocco	0	0.1	20	18.8%	13.9%
South Africa	0	0.9	75	5.2%	4.8%
Median			***75***	***17.5%***	***7.8%***

97.9% wind. Overall, Alberta is 89% powered by fossil fuels[xliv]. So even within Canada, the availability of oil, gas and coal in certain provinces appears to have depressed the adoption of renewables.

Canada has a variety of renewable incentives programmes, including renewable portfolio standards, competitive auctions, feed-in tariffs (both technology-specific and agnostic), net metering, tax breaks, loan guarantees, renewable certificates and time-of-use power pricing (favouring daytime solar generation)[xlv].

Canada has a federal carbon tax (CA$20/tonne, rising to CA$50/tonne by 2022), and the provinces also have a variety of their own carbon charges. The tax increased to CA$30/tonne on 1st April 2020 as planned, despite the coronavirus outbreak[xlvi], although Alberta is challenging the validity of the tax in court[xlvii].

Norway's electricity generation has historically been almost entirely from hydropower. Perhaps as a result, it was relatively slow to adopt wind power, despite its excellent resources, while the use of solar is negligible. Wood is the second most popular home heating method after electricity, though there are concerns about urban air pollution . District heating supplies about 10% of total heating needs, and most of this is fuelled by waste and biomass[xlix].

Its National Renewable Action Plan, submitted in 2012 in conformance with European legislation, plans for renewables to meet 67.5% of final energy, 43% of heating, 114% of electricity demand (including exports) and 10% of transport energy by 2020[l].

OIL & GAS PRODUCERS HAVE DIFFERENT EXPERIENCES WITH RENEWABLES

The main policy to achieve these targets is a scheme of renewable generation certificates jointly with Sweden. Norway was an early adopter of a carbon tax, which was introduced on the oil industry in 1991, and it joined the EU ETS in 2008.

Norway is also usually a significant net exporter of electricity of about 10% of its generation, therefore helping to boost the renewable share of its neighbours. A 1.4 GW undersea grid connection to the UK is being built, and the country is also electrifying its offshore oil platforms. It can balance variable renewable output using its hydro installations as pumped storage.

Norway's state oil company, Equinor (previously Statoil) has become a pioneer of floating offshore wind, building on its experience of floating oil installations in the North Sea[li]. Its investments in low-carbon energy are intended to increase to 15-20% of its overall budget by 2030. State power firm Statkraft is also investing extensively in international solar and wind[lii] . There is a variety of direct subsidies and grants for renewable R&D, such as the Offshore Energy Act[liii]. Norway intends to be a major exporter of renewable technologies and finance.

Overall, the country's oil and gas resources have not impeded renewable adoption; on the contrary, high income levels have encouraged pro-environmental policies. The country is the world leader in the share of electric vehicle sales through generous incentives.

The Gulf Cooperation Council countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, UAE) were slow to move on renewable energy, but in recent years have begun using auctions for large-scale procurement of solar and, to some extent, wind. Several GCC

countries also have rooftop solar policies offering net metering at standard retail rates, but not subsidies. Oman has commissioned solar thermal on a large scale for steam generation in enhanced oil recovery. In most cases, the national energy ministry and/or state utility company has contracted for the renewable projects, not the national oil company. There are also a number of private companies specialising in smaller commercial and industrial solar installations, which have expanded internationally to markets elsewhere in the Middle East and Africa.

WHAT SHOULD MAJOR HYDROCARBON PRODUCERS LEARN FROM THIS?

Renewables can be complementary to petroleum production, as shown in Oman's solar steam, solar PV for remote installations, electrification of offshore platforms, and concentrated solar steam for use in oil-field processes and refineries.

Many oil and gas exporters are in hot, arid regions where desalination is vital. This has traditionally been provided by energy-intensive thermal desalination (multi-stage flash and others), usually with cogeneration of electricity. Reverse osmosis desalination, running on electricity, is less energy-intensive and more flexible. Desalination with renewable electricity, or directly with solar heat, can be an environmentally friendly option.

Finally, oil and gas exporters may be concerned that renewables may affect the market for their products. While this is true, in principle, experience shows that renewables could be complimentary to fossil fuel, especially gas.

Gas will remain important for a significant period as a complement to variable renewables in power, because of gas turbines' flexibility, but this will be at lower load factors and hence lower total consumption.

Case Study Jordan and Morocco

- Jordan and Morocco have minimal amounts of fossil fuels, and historically have faced challenges with high and volatile prices for imported oil and gas and energy security concerns.
- Morocco has some hydropower, but a high dependence on coal. Jordan has minimal hydropower and suffered from repeated interruptions to gas supplies from Egypt due to sabotage.
- By 2019, Jordan had installed 373 MW of wind and 998 MW of solar PV, from about 3800 MW of total installed generation. Morocco has 1306 MW of hydro, 1220 MW of wind, 206 MW of solar PV and 530 MW of solar thermal, from about 6000 MW of total capacity.
- Morocco's 2009 National Energy Strategy targeted 42% renewable capacity by 2020, and this was raised in 2015 to 52% by 2030, a target that has already been exceeded. It established a national renewables agency, MASEN. Morocco has also sought training and technology development.
- Jordan's renewable energy law provided for tax incentives, net metering and 'wheeling' of power through the national grid. Projects can be awarded by competitive auctions, by direct proposals to government from developers, or by self-generation for small installations.

- Jordan has faced challenges with the high cost of early-signed power purchase agreements, potential over-commitment, and a lack of transmission infrastructure from remote generation sites. A new 'green corridor' is addressing the transmission issue.
- Neither country has renewable policies for heating/cooling or biofuels/transport.
- These two countries have demonstrated the viability and cost-competitiveness of solar PV, solar CSP and wind in the Middle East and North Africa (MENA) region. This has been valuable experience for neighbouring countries to learn from.

THE WAY FORWARD FOR GLOBAL RENEWABLES POLICY

The success of renewables policies worldwide has raised new challenges. Lessons from the first generation of supports provided to renewables can be applied to new policies, and to countries where renewables have so far not taken off. Agencies such as IRENA, and international development banks, play a key role in bringing expertise and finance to countries with low use of renewables.

Some renewables are becoming mainstream and competitive on cost and performance with fossil-fuelled generation. This means that subsidies and feed-in tariffs may no longer be required, and a complex web of incentives, mandates and tax breaks could be simplified. A comprehensive carbon tax or trading scheme may suffice to ensure sufficient uptake of low-carbon generation. Auctions could become technology-agnostic, as long as allowance is made for the different levels of dispatchability and seasonality. In general, market-based instruments (auctions, tradable certificates) may become more popular over mandates and subsidies because of their greater efficiency and transparency.

There may need to be a significant adjustment between the current policies that have achieved a world share of about 25% of electricity generation (including hydropower), and those required to get to 80-100% of all energy. For instance, cross-border and long-distance electricity trade has to make increasing use of complementary timings and resource endowments.

THE WAY FORWARD FOR GLOBAL RENEWABLES POLICY

Electricity markets need to be reshaped to deal with a high share of variable renewables and, likely, a large quantity of required storage. Time-of-day or even real-time pricing, smart meters, grids and homes, and demand management (including grid-connected electric vehicles) all have to be integrated.

Emerging new technologies, such as niche renewables and supporting systems like smart grids and advanced batteries, may need specific policies to help them bridge the 'valley of death' between small-scale R&D and pilots, and large-scale commercial deployment. This is most likely to involve direct government subsidies or procurement, who may need to avoid the risk of attempting to 'pick winners'.

Renewables have also not always lived up to their promise to promote wider socioeconomic and technological progress. This applies where initial leaders in the sector have found themselves outcompeted by foreign, often Chinese, newcomers. Solar and wind may create large numbers of jobs in the installation phase but require very little during operation.

Renewables policies should be tailored locally, but successful approaches can be applied internationally. There is room for more international cooperation on renewable technologies, trade, and the development of markets and supply chains for emerging commodities such as lithium, rare earths and hydrogen.

The challenges for the 2020s will be to accelerate renewables installations to match the rates required by climate policy; integrate a much higher share of renewables at reasonable cost, including beyond the electricity sector; and deliver on the broader socioeconomic promise.

APPENDIX

i.Data from BP Statistical Review of World Energy 2019

ii. Data from https://data.ene.iiasa.ac.at/iamc-1.5c-explorer/#/workspaces/2

iii. Data from https://data.ene.iiasa.ac.at/iamc-1.5c-explorer/#/workspaces/2

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x.Data from BP Statistical Review of World Energy 2019

xi. Data from BP Statistical Review of World Energy 2019

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xiii. Data from BP Statistical Review of World Energy 2019

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THE ABDULLAH BIN HAMAD AL ATTIYAH FOUNDATION

Barzan Tower, 4th Floor, West Bay, PO Box 1916 - Doha, Qatar

Tel: +(974) 4042 8000, Fax: +(974) 4042 8099
www.abhafoundation.org

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The Al-Attiyah Foundation