WORLD ENERGY COUNCIL | FUTURE ENERGY LEADERS

A Fresh Perspective:

Emerging Opportunities Confronting Climate Change | 2018

ABOUT WORLD ENERGY COUNCIL - FUTURE ENERGY LEADERS

The World Energy Council is the principal impartial network of energy leaders and practitioners promoting an affordable, stable and environmentally sensitive energy system for the greatest benefit of all. Formed in 1923, the Council is the UN-accredited global energy body, representing the entire energy spectrum, with over 3,000 member organizations in over 90 countries, drawn from governments, private and state corporations, academia, NGOs and energy stakeholders. The World Energy Council inform global, regional and national energy strategies by hosting high-level events including the World Energy Congress and publishing authoritative studies, and work through our extensive member network to facilitate the world's energy policy dialogue.

The Council's Future Energy Leaders form a community of exceptional young professionals from across the globe representing the different players in the energy sector, composed of, government, energy industry, academia, civil society and social entrepreneurs. This community of young professionals share a commitment to shape the global energy future. Further details at www.worldenergy.org/wec-network/future-energy-leaders/

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ABOUT A FRESH PERSPECTIVE: EMERGING OPPORTUNITIES CONFRONTING CLIMATE CHANGE | 2018

A Fresh Perspective: Emerging Opportunities Confronting Climate Change | 2018 was produced by Future Energy Leaders –Climate Change Taskforce.

This report details climate change impacts both in terms of risks and opportunities. Aiming at managing the risks and scoping new opportunities, four main mechanisms are identified for the energy sector:

(i) Economy wide mechanisms

(ii) Support mechanisms

(iii) Regulatory policies

(iv) Enabling instruments

The Climate Change Taskforce has completed this report, including recommendations for governments and private sector stakeholders to do more, and present potential opportunities in this energy transition.

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EXECUTIVE SUMMARY

Climate change is a reality that can no longer be ignored. According to the World Economic Forum, climate risks are more prominent than ever, strongly connected with other risks, such as conflicts and migration. Decarbonising the energy sector is crucial in attaining the goal of limiting the average increase of global temperature well below 2°C. According to the International Energy Agency, reaching a coherent scenario with this goal would mean that greenhouse gas emissions would have to fall by more than 70% from today's levels by 2050. Technological changes in areas such as renewable energy resources, energy efficiency, smart grids, sustainable transportation, demand-side management and energy storage are already causing disruption, facilitating the decarbonization process.

Governments are a key agent to accelerate the energy transition. Policymakers have to introduce long term perspectives in the political debate, through ambitious climate targets, well-defined plans to reach them, but also implementation procedures to make them real. Every step that is taken should have an eye towards long-term goals. Timing is critical and early action is the only way to achieve the climate goals. Governments need to introduce the right market signals that allow both the internalization of all environmental costs, and the stability needed for the deployment of low carbon technologies and energy efficiency measures. Eliminating all barriers and price distortions, especially fossil fuel subsidies, is important to create a level playing field for sustainable solutions. Climate Change Taskforce believes carbon-pricing mechanisms are the most relevant tool that governments have to send out a strong signal that can promote the transition. For this to happen, these mechanisms have to be designed according to the "polluter pays" principle, covering all economic sectors. The Paris Agreement can contribute to the expansion of carbon pricing initiatives as well as create new possibilities of cooperation among mechanisms and countries. Cooperation is a key element to facilitate the fulfilment of national contributions.

The private sector, with its financial leverage and capability for innovation, must play a leading role in a greener future, working with governments. We are all moving to a world where going green can make economic sense. Decarbonizing our economies is not only feasible but also desirable. Climate change is creating opportunities for companies willing to innovate. Renewable energies and energy efficiency measures (with massive cost reductions) are recent examples of climate-related areas expecting growth. However, there are many others like sustainable transportation, green finance and resilience infrastructure development. Going green goes further than just investing in sustainable solutions. It is necessary that the private sector integrates climate change in its business strategy, carrying out a thorough assessment, informing on the level of exposure, and enhancing the disclosure level. Voluntary platforms to settle on plans on the appraisal of climate-related risks are good examples of the right steps the energy industry should take. It implies a profound transformation across key sectors of the economy, with implications for economic growth, job creation, and health, representing a clear opportunity to enhance competitiveness and boost new business models. These transformations will happen only with public and private engagement and support.

This report has been prepared to give an insight for emerging opportunities confronting climate change in today's world by the members of Climate Change Taskforce - Future Energy Leaders. The recommendations of the report have been presented by Climate Change Taskforce at the World Energy Leaders' Summit (Lisbon, Portugal, October 2017) in a dedicated panel discussion session on climate change.

KEY FINDINGS

- As of April 2018, 176 Parties representing almost 89% of global greenhouse gas emissions have already ratified the Paris Agreement.

- The “Paris Rulebook” needs to standardize countries' accounting procedures, and it needs to be done by 2018, according to the Paris Agreement's timeline.

- According to the joint report of IRENA and IEA, the share of fossil fuels in primary energy demand would have to halve by 2050, while the share of low carbon sources would have to increase to 70% of energy demand. In addition to that, renewable energy and energy efficiency measures would play a major role, being potentially able to account for 90% of required carbon reductions.

- The cumulative economic cost of changes to the physical environment, health and food security is estimated to be in the range of US$1.5 trillion to US$3.7 trillion to 2030 with costs rising.

- As environmental sustainability is inevitable, new business models perpetuate “cradle to grave” approaches that are driven simply by reducing carbon footprint.

- Solar photovoltaic (PV) technology has become one of the key players among the new business models related to clean energy around the World, because of its benefits not only at a utility scale but also at customer level.

- Technology transfer will be a key element to ensure less developed countries can meet their energy needs in a sustainable way.

- In addition to the promotion of renewable energy sources, energy efficiency stands out as one the most fundamental pillars of the global decarbonisation efforts.

- Leading organizations from the energy sector have clearly pointed out the outstanding amount of resources needed to invest in the transition to low carbon energy system.

RECOMMENDATIONS

- Carbon pricing mechanisms should be designed according to the polluter pays principle, covering all economic sectors.

- The Paris Agreement needs to facilitate the expansion of carbon pricing initiatives as well as possibilities of cooperation among mechanisms and countries.

- Governments must eliminate all barriers and price distortions, especially fossil fuel subsidies to create a level playing field for sustainable solutions.

- Governments need to focus towards long-term climate goals. Policy certainty and stability is needed for the deployment of low carbon technologies, to achieve the required growth in renewable energy, particularly in developing and emerging nations.

- The private sector, with its financial leverage and capability for innovation, must play a leading role in a greener future.

- Energy efficiency should be at the core of actions to meet the commitments of the Paris agreement.

- Private sector needs to integrate climate change in its business strategy, carrying out a thorough assessment, informing on the level of exposure, and enhancing the disclosure level. Voluntary platforms to settle on plans on the appraisal of climate-related risks are good examples of the right steps the energy industry should take.

INTRODUCTION

The Paris Agreement, entering into force on November 2016, was an unprecedented milestone in the global action against climate change as the world came together for the first time to address this global challenge collectively. The success of this agreement has been underpinned by a new mixed governance system, top-down/bottom-up with Nationally Determined Contributions (NDCs) as the key element in meeting the long term goal of keeping the increase in global average temperature to well below 2°C above pre-industrial levels. As of April 2018, 176[1] Parties representing almost 89% of global greenhouse gas emissions have already ratified the Paris Agreement.

"Facing uncertainty, keeping the momentum and implementing Paris Agreement"

Important progress towards the Paris Agreement's implementation continues, mainly on guidelines, "Paris Rulebook", across a wide range of issues including transparency, adaptation, emission reductions, provision of finance, capacity-building and technology (World Economic Forum, 2017). The "Paris Rulebook" will establish the more technical rules and processes needed to fulfil the Paris Agreement's ambitions. Important progress towards the Paris Agreement's implementation is ongoing, mainly on guidelines (*"Paris Rulebook"*), across a wide range of issues including transparency, adaptation, emission reductions, provision of finance, capacity-building and technology. These guidelines were discussed during COP23 in Bonn, with the aim to be completed by COP24 in Poland in 2018, being crucial to articulate the facilitative dialogue, which will take place there, to review NDCs every five years (the first one will be in 2023). One of the main topics on the table is related to cooperative approaches (under article 6 of Paris Agreement) and the use of the Internationally Transferred Mitigation Outcomes (ITMOs), looking for higher ambition and promoting, at the same time, assisting sustainable development in less developed countries.

THE CHALLENGE AHEAD: TO MEET ≤ 2°C SCENARIO

Limiting the increase of the global temperature to well below 2°C requires unprecedented efforts to reduce greenhouse gas emissions, implying an energy transition of the importance to the one that occurred during the industrial revolution. International Renewable Energy Agency (IRENA) and International Energy Agency (IEA) have conducted a joint report that analyses coherent scenarios towards reducing energy sector emissions in line with the 2°C target. In the IEA, the analysis includes *66% 2°C Scenario,* which aim to illustrate pathways towards energy sector decarbonisation that are technology-neutral and include all low-carbon technologies, taking into account each country's own circumstances. The *New Policies Scenario* by IEA reflects the implications for the energy sector of the climate pledges, known as Nationally Determined Contributions (NDCs), which were made as part of the Paris Agreement (World Economic Forum 2017).

The *66% 2°C Scenario* outlines a path for limiting global temperature change by 2100 to reach "well below 2°C" target with a 66% probability. The outlook for CO2 emissions in the *66% 2°C Scenario* represents a very sharp contrast with that of the *New Policies Scenario*. In the *New Policies Scenario*, CO_2 emissions continue to increase to reach slightly more than 37 Gt by 2050. Cumulative energy-related CO_2 emissions between 2015 and 2050 in the *New Policies Scenario* are around 1,250 Gt, about 75% higher than the carbon budget consistent with a 66% chance of keeping the temperature rise below 2°C.

The power sector provides the largest contribution to global CO2 abatement, accounting for around half of the cumulative abatement relative to the *New Policies Scenario* between 2014 and 2050. The transport sector would provide the second-largest contribution to CO2 savings, accounting for around 20% of the cumulative savings between 2014 and 2050 in the *66% 2°C Scenario*. The industry sector would provide around 17% of the cumulative emissions savings in the period to 2050 (Figure 1).

To meet the well below 2°C target, the share of fossil fuels in primary energy demand would have to halve by 2050, while the share of low carbon sources would have to increase to 70% of energy demand. Energy intensity would improve significantly in order to enable energy demand to remain around today's levels by

[1] Paris Agreement – Status of Ratification: http://unfccc.int/paris_agreement/items/9444.php

2050 while carbon intensity of energy use would decline drastically, with a reduction of more than 90% compared to today's level. In this transformation, renewable energy and energy efficiency measures would play a major role, being potentially able to account for 90% of required carbon reductions.

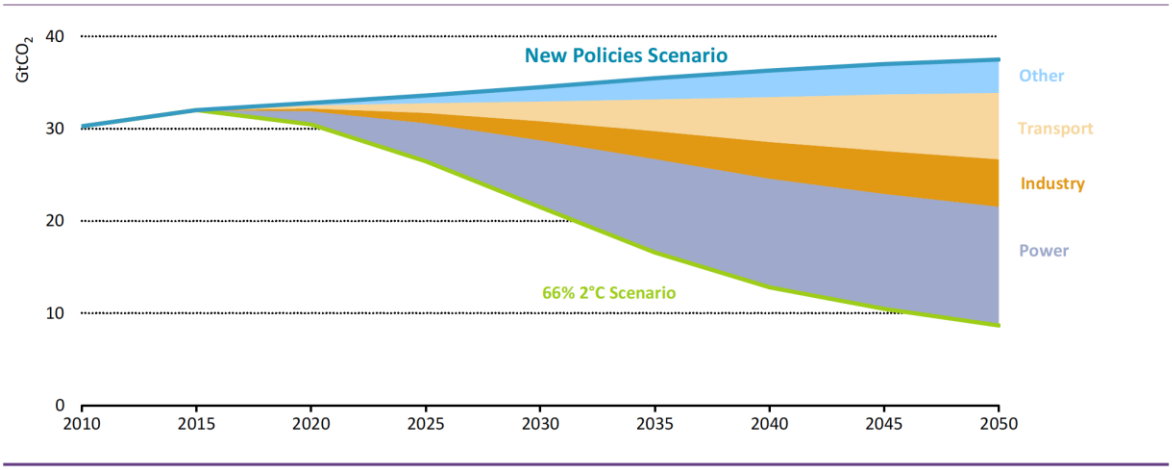

Figure 1. Global CO_2 emissions abatement by technology in the 66% 2°C Scenario relative to a New Policies Scenario (IEA and IRENA, 2017).

CLIMATE RISKS AND NEW OPPORTUNITIES

Brauner wrote, “Risk is possible loss and opportunity is possible gain. Since climate is the weather average, we can apply the term climate risks to the possible increase in average weather-related damage and losses. By analogy, climate opportunities comprise the possible increase in the average weather-related gains in material or emotional terms” (Brauner 2002).

The Paris agreement highlights the critical role of innovation in addressing climate change and in particular the importance of collaborative approaches. The following sections review climate risks in four main areas; physical, technological, regulatory and social; and climate opportunities in the form of innovation, new technologies and markets, access, diversity, capability and collaboration.

CLIMATE RISKS - BUSINESS AS USUAL NO LONGER AN OPTION

According to the World Economic Forum[2] climate risks are now more prominent than ever, being in the top five on all the rankings in terms of likelihood and impact, strongly connected with other risks, like conflicts and migration. Although climate risks are unlikely to fully materialize in the short term, being under-priced or underappreciated, they will be significant in the medium and long term. It is important to bear in mind the impacts derived from climate change itself and the risks associated to a late and sudden transition towards a low-carbon economy.

“Climate change is a risk for the economy as a whole and for the industrial and financial sectors in particular”

Climate risks can be divided in four main areas:

- Physical Risk
- Technological Risk
- Regulatory Risk
- Social Risk

Physical risks: Physical climate risks are already showing up in two ways: 1) more frequent, intense extreme weather events such as storms, flooding, droughts and wildfires; 2) creeping rises in temperatures and sea level / erosion over time and effects to coastal zone economic activity, ultimately triggering second-round effects on other sectors of the economy (Erickson 2015). The cumulative economic cost of changes to the physical environment, health and food security is estimated to be in the range of US$1.5 trillion to US$3.7 trillion to 2030. Delaying activity increases the cost and makes a well-coordinated policy-response difficult. . The physical damage from climate change could shave 5–20% off global GDP annually by 2100 (Kepler 2014).

Technological risk: Anything built from now on that produces emissions will most probably do so for decades, and this lock-in effect will be the single factor most likely to produce irreversible climate change. The existing fossil fuel infrastructure is valued at US$15 trillion worldwide and investment in it continues to increase, creating economic, financial, and socio-political lock-ins, hindering our climate objectives (IEA & IRENA 2017). The World Resources Institute estimates to meet the 2°C warming goal, three-quarters of proven coal, oil and gas reserves would have to remain untapped. Assets could be effectively “stranded” — with their owners exposed to write-downs.

[2] World Economic Forum - Global Risks - http://reports.weforum.org/global-risks-2017/global-risks-landscape-2017/#risks///

According to Kepler in a consistent scenario with the 2°C target, the fossil-fuel industry would have to face a potential loss of US$28 trillion (in constant 2012 US dollars) of gross revenues over the next two decades, compared with business as usual (Kepler 2014).

Regulatory risk: Today there are over 1,200 climate change relevant laws worldwide, a twentyfold increase over 20 years. Existing climate laws already cover a large amount of ground and countries differ in their approach to climate policy. Dealing with climate change will require clear emissions reduction targets, stricter environmental regulation and higher standards. These new regulations pose increased regulatory risks not only by the inclusion of new barriers limiting business activity but can also perverse signals for the economic activity.

Social risk: Climate change awareness is changing social perception, putting sustainability on the business agenda. Society can increase pressure on firms to make changes in their supply chains. This new environment is translated into changes in consumer behaviour, where customers are looking for sustainable options, penalising those who lack action. The life cycle assessment (LCA) has become a reputable tool for assessing the environmental footprint of products and services. The majority of companies adopt partial life cycle assessment so called “gate-to-gate” that covers environmental effects of operations in specified area. Recently, due to the rise in the circular economy model thinking, the cradle-to-grave approach has been gaining interest in LCA studies. This reveals the entire environmental impact of firms from product and service systems starting with the ‘birth’ (extraction of raw material) stage, up to the ‘death’ (the end-of-life disposal process, such as incineration, landfilling, recycling or reuse) phase (Halimah et al., 2009). New business models perpetuate cradle to grave approach that is driven simply by reducing carbon footprint, e.g. using less energy in manufacturing process and reducing pre-consumer waste.

NEW OPPORTUNITIES – GOING GREEN CAN MAKE ECONOMIC SENSE

Climate Opportunities can be divided in three main areas:

- New Markets,
- Innovation & New Technology
- Access, Diversity, Capability and Collaboration

New Markets: To achieve a well below 2°C target scenario renewable energy will need to increase its share of primary energy demand from 15% to around 65% by 2050, with wind and solar combined becoming the largest source of electricity by 2030. Solar photovoltaic (PV) technology has become one of the key players among the new business models related to clean energy around the World, because of its benefits not only at a utility scale but also at customer level. Solar PV cost reduction has given people the opportunity of producing their own energy at their place, using a clean, renewable and inexhaustible source, while cutting down their energy costs. In some cases, it is possible to sell your energy production surplus back to the grid, making it a profitable investment. Therefore solar PV plays a major role in terms of energy access since it does not require huge transmission lines, allowing small villages to generate their energy off grid. 75 GW of solar were installed globally in 2016 – bringing the installed global PV capacity to at least 303 GW. That equates to producing 1.8 % of the electricity demand of the planet[3].

The massive emissions cuts in the power sector would encourage the electrification of the economy, reducing the direct use of fossil fuels in end use sectors. Electricity share in final energy consumption has to rise to 30% by 2050 facilitating the renewable sources integration and the energy transition in sectors like transport, buildings and industry.

[3] Green Tech Media 2017 - www.greentechmedia.com/articles/read/iea-global-installed-pv-capacity-leaps-to-303-gw

A rising middle class is forecast to increase the number of vehicles (commercial vehicles and passenger cars) from 1.4 to 2.3 billion units, by 2035, with more than 80% of the growth coming from outside the OECD[4]. Overall, 80% decarbonisation by 2050 may require 95% decarbonisation of the road transport sector (McKinsey 2009). Electric vehicles (EV) must therefore grow to 70% of new cars by 2050, assisted by government policy, such as those visible in the EU. Greater EV penetration will have an impact on oil prices and CO_2 emissions. Exponential advances in EVs (batteries), coupled with driverless cars and new mobility services, will trigger a slide in demand for traditional cars; potentially much quicker than markets expect.

Electric vehicles have zero tail-pipe emissions, significantly improving local air quality. EVs can be made close to CO_2-free over time, and on a well-to-wheel basis, depending on the primary energy used in their manufacture. Zero-emission power-trains therefore go hand-in-hand with the decarbonisation of energy supply, with the potential to significantly reduce emissions from central power and hydrogen production by 2050.

Innovation: Renewable sustainable technologies will play a major role in decarbonizing our energy system, however renewable technologies, such as wind and solar are intermittent, dependent on weather conditions. Capturing carbon dioxide and combining it with hydrogen from excess, curtailed or constrained renewable energy to produce synthetic methane, will ensure a potential green gas alternative, together with replanting our global forests and Carbon Capture & Storage (CCS) technologies are long-term solutions to combat climate change. However, advances in battery technology could help electric grids better match renewables supply with demand. Widespread deployment of battery energy storage may make financial sense as soon as 2020, rather than previous estimates of 2045.

Energy Demand Response is not a new concept. The balance of supply and demand is essential for any market and demand response has provided a method for reducing demand in the electrical grid at points (and times) where supply is limited. The IEA emphasises the need to deploy demand response technologies and the importance of increasing the demand elasticity through price signal responsiveness. A large deployment of demand response technologies will also have to address data privacy challenges and foster the development of smart metering and automated technologies.

At least 45 countries worldwide had renewable heating and cooling targets in place by year-end 2015, with 31 of these in Europe. In 2015, the adoption of policies promoting the development and deployment of renewable energy technologies in the heating and cooling sector continued to lag behind policy adoption in the power and transport sectors. However, some leading jurisdictions have begun to recognise the important role that renewables can play in transforming the heating and cooling energy mix and have established regulatory and financial mechanisms to support technologies such as solar water heaters, combined heat and power (CHP) or modern biomass heat. It is also important to accelerate the energy efficiency improvements on buildings using all the tools that telecommunication technologies can offer.

Access, Diversity, Capability and Collaboration: Many companies want to buy power directly from sustainable sources. Renewables allow buyers to lock in power prices for 20 years, without exposure to commodity price swings. This shift creates opportunities, particularly in renewable infrastructure with stable, long-term income, which has already eroded traditional utilities' credit ratings and ability to pay dividends. According to Mckinsey, low-carbon energy has already become cost competitive and less reliant on subsidies, for example offshore wind projects in 2017 in the Netherlands and Denmark are falling below 50 €/MWh (McKinsey 2017), being over 200€/MWh the average electricity retail price for households and over 110€/MWh for companies in the UE-28 in 2017.

[4] BP Statistical Abstract , 2014 - http://newclimateeconomy.report/2016/

Even though the energy supply will change substantially, fossil fuels will continue to play a role in the energy transition. Natural gas can be the transition fuel but there is a risk of lock-in effect and future stranded assets if long-term emissions reduction targets are not taken into account while investing in gas infrastructure and deployment. A transition like this would require additional investment in its fundamental axes. Many of the new players are too speculative to be investable yet or need a catalyst such as carbon pricing or a reduction in fossil fuel subsidies. Competition, especially from China, also could drive margins lower.

Additional US$29 trillion of cumulative investment is needed to meet the Paris Agreement goal. This additional investment would be added to US$116 trillion considered in the Reference Case for the same period. The investment efforts in Research and Development (R&D) should be made, the sooner the better, so enough time is given to develop new solutions. It is also important to point out that climate change will force governments to invest in improving the resiliency of infrastructure. According to Stern, we are expected to invest about US$90 trillion in infrastructure until 2030, requiring a shift to ensure that all funds are spent both on sustainable and resilient infrastructures and low-carbon and energy-efficient projects (Stern 2007).

Technology transfer will be a key element to ensure less developed countries can meet their energy needs in a sustainable way. It is important to take into account that more than 1 billion people still have little or no access to electricity and over 3 billion people do not have access to clean cooking. Public-Private Partnerships (PPPs) in the energy sector come in different shapes, sizes and structures and are used mainly in generation and transmission. The methodology used varies, depending on the country, the government and the specifics of the operation; therefore each one is tailored to the needs and circumstances given at the time when the partnership is created.

MECHANISMS TO INITIATE CHANGE

The appropriate management of the risk and the development of the opportunities described in the previous chapters will rely on the adoption of a wide range of policy instruments. For descriptive purposes we distinguish and highlight four types:

- Pricing mechanisms over carbon emissions
- Standards on technological, environmental or performance criteria which are also being called "command and control instruments"
- Support mechanisms from which subsidies are the most widely used
- Financial market instruments to allocate capital away from high carbon and into low carbon ventures.

ECONOMY WIDE MECHANISM: THE CASE OF CARBON PRICING

Internalizing external costs by giving them a price is the basic idea of pricing mechanisms. This concept is most used and developed for putting a price on emitting greenhouse gases, thus carbon pricing. There are two main types of carbon pricing mechanisms: a carbon tax where the price of carbon is determined by an authority (a regional, national or local government namely) or an Emissions Trading System (ETS) where the price is determined by overall capping and then trading carbon certificates in a carbon market. By 2015, a total of 39 national and 23 subnational states and regions had implemented at least one of these instruments, or a mix of both, which translates to about 13% of global emissions in 2015.

Recommendation: Carbon pricing mechanisms should be designed according to the polluter pays principle, covering all economic sectors.

Emissions trading systems are the most common method for carbon pricing. The biggest carbon market is the European one, the EU ETS, in place since 2005. Another very large carbon market is the Chinese one that is in the process of evolving from an eight cities/regions pilot phase into a national market in 2017, easily becoming the largest carbon market. A very well-known and functioning carbon market is the one of California in the United States. However, the ETS mechanism is not limited to countries. The International Civil Aviation Organization has taken steps to achieve the global aspirational goal of carbon-neutral growth from 2020 onwards by recommending adopting a new global market-based measure to control CO_2 emissions.

Recommendation: The Paris Agreement needs to facilitate the expansion of carbon pricing initiatives as well as possibilities of cooperation among mechanisms and countries.

It is important to consider that besides explicit pricing instruments such as a tax or a trading scheme, carbon policies also have an implicit carbon price. A key element here is the question if fossil fuels are subsidized or not – in whatever way. Such an implicit carbon price is very difficult to calculate or estimate. According to Wagner and Weitzman, despite efforts made and because of subsidies to fossil fuels, there is still a "great disparity between regions, but on average global price is closer to negative US$15/ton". This finding reflects the challenges around effective carbon pricing mechanisms which fully reflect the "polluter pays principle" and take into account all explicit and implicit costs of emitting GHG.

SUPPORT MECHANISM: THE CASE OF RENEWABLE ENERGY

Energy, especially power, is a highly policy-dependent market, deeply influenced by regulation, incentives, and public goals. Policies and regulations are pivotal in expanding market development in this sector. Notably, year 2017 saw nearly all countries supporting renewable energy development and deployment directly via a combination of policies sanctioned at the national, sub-national and local levels. Policymakers continued to implement a range of renewable energy targets and support mechanisms to draw investment, propel deployment, promote innovation, boost more flexibility in energy infrastructure and support the development of enabling technologies such as energy storage. As the renewable energy sector matures and grows, policies are increasingly being adapted to befit shifting market conditions. A wide-ranging suit of policies, such as feed-in tariffs (FITs), tendering, net metering and fiscal incentives have been implemented to usher in the use of more low-carbon power in a country's energy mix. Policy support gravitates mostly to the power sector, whereas support for renewable technologies in the heating/cooling and transport sectors has grown at a slower pace.

With regards to Solar PV, stable and well-designed deployment policy was a pivotal factor in driving system prices downwards in Germany and China, both by enabling the industries to achieve economies of scale as well as lowering transaction and finance costs. Similarly, in India, state policies and regulations (in particular, FITs) were a vital element in developing the wind industry. Crucially, what has been a winning approach in such countries that have attained success has been ensuring that key low-carbon energy strategies are increasingly integrated into national economic development objectives. Policy uncertainty continues to be one of the principal hindrances to ubiquitous growth in renewable energy, particularly in developing and emerging nations. Investment in renewable energy is contingent on support mechanisms that underpin returns and limit risks for project developers, as well as finance. Evidence points to markets in most locations being driven largely by government policies demonstrating the vital role of consistent long term policy.

With respect to renewable heating and cooling technologies, policy makers continued to emphasize financial incentives such as grants, loans or tax incentives. In addition, some enacted policies designed to advance technological development have not become law due to policy uncertainty.

Recommendation: Governments need to focus towards long-term climate goals. Policy certainty and stability is needed for the deployment of low carbon technologies, to achieve the required growth in renewable energy, particularly in developing and emerging nations.

Since the early 2000s, the roll-out of renewable energy technologies has been strongly correlated with subsidies. However, fossil fuel subsidies continue to dwarf that of clean energy. A recent report estimates

that G20 governments provide four times more public financing to fossil fuels than to renewables (OCI 2017). Fossil-fuel subsidies and taxes continue to distort energy markets, tipping the scales in their favour. Encouraging investments through market restructuring is imperative. Reducing market discrimination against renewables can eliminate the need for investment support. There is also the issue of how investors in new, unsubsidised wind and solar projects can de-risk future revenues in an environment where subsidies dwindle.

Recommendation: Governments must eliminate all barriers and price distortions, especially fossil fuel subsidies, to create a level playing field for sustainable solutions.

Even though FITs remained the most widely utilized form of regulatory support to the renewable power sector, significant recent policy trends have witnessed the gradual shift in the power sector from tariff-based mechanisms to auctions. Tenders (competitive bidding or auctions) for renewable energy are the most rapidly expanding form of support for renewable energy project deployment, overtaking subsidy programmes as the principal means of allocating renewables capacity, thereby becoming the preferred policy tool for supporting deployment of large-scale projects.

Research by Bloomberg New Energy Finance suggests that, on average, there is a 30% reduction in renewable energy project tariff when a country shifts from a feed-in tariff or green certificate programme to its first auction (BNEF 2015). Markedly, the generosity of renewable subsidies has been lessening as technologies such as wind and solar have become more cost-competitive. Auctions around the world have resulted in unthinkable tariffs for solar and wind projects in 2016, the lowest being Solarpack's deal in Chile to sell power from a 120 MW PV project at US$29/MWh. Morocco also established a new record for wind, at US$30/MWh, in an 850 MW tender. The success of these winning bids is by far the most promising indication of the future greening of the world's power system.

Regarding transport, electric vehicle grants and biofuel blend mandates and financial incentives remain the most common forms of support. Despite ongoing debates over biofuel production and use, including sustainability concerns, biofuel support policies were adopted in numerous countries throughout 2016. Denmark's advanced biofuels mandate pointed to increased policy support for the use of advanced biofuels.

Recommendation: The private sector, with its financial leverage and capability for innovation, must play a leading role in a greener future.

REGULATORY POLICIES: THE CASE OF ENERGY EFFICIENCY

In addition to the promotion of renewable energy sources, energy efficiency stands out as one the most fundamental pillars of the global decarbonisation efforts. Annual energy intensity improvements of 3.7% are needed between now and 2030 (IEA 2016a). In addition to curbing emissions, energy efficiency also brings numerous other benefits, such as increasing energy security, improving air quality and saving significant financial resources, which would otherwise be spent on expanding the energy production capacity to meet the globally growing demand. Energy efficiency is the only energy resource possessed by all countries, and it will be at the core of actions to meet the commitments of the Paris agreement.

The global energy intensity improved by 1.8% in 2015, surpassing the 1.5% gain seen in 2014, and tripling the annual rate (0.6%) seen in the previous decade (IEA 2016b). Nevertheless, much more needs to be achieved to meet the climate targets.

The experience of the recent three decades demonstrates that energy price alone is not sufficient to cut energy consumption – efficient policy is the most important tool to deliver energy savings. National policies are particularly necessary during the times of low energy prices, which undermine the prospects of private investments into energy efficiency measures. Most of the globally implemented energy efficiency policies could be grouped in the following categories:

- Mandatory standards (e.g. minimum energy performance standard)
- Mandatory energy savings targets and obligations
- Labelling and information
- Financial incentives
- Financial disincentives (e.g. energy taxes or carbon prices)

In 2015, mandatory energy efficiency policies (performance standards and mandatory targets) covered 30% of the world's energy consumption, up from 11% in 2000 (IEA 2016a). Despite the progress, two thirds of the global energy consumption is not subject to any efficiency requirements. The sign of optimism can be found in the Nationally Determined Contributions, where about 75% of the countries mention energy efficiency (Figure 2). Nevertheless, only a few specified concrete targets or performance standards (IEA 2016a).

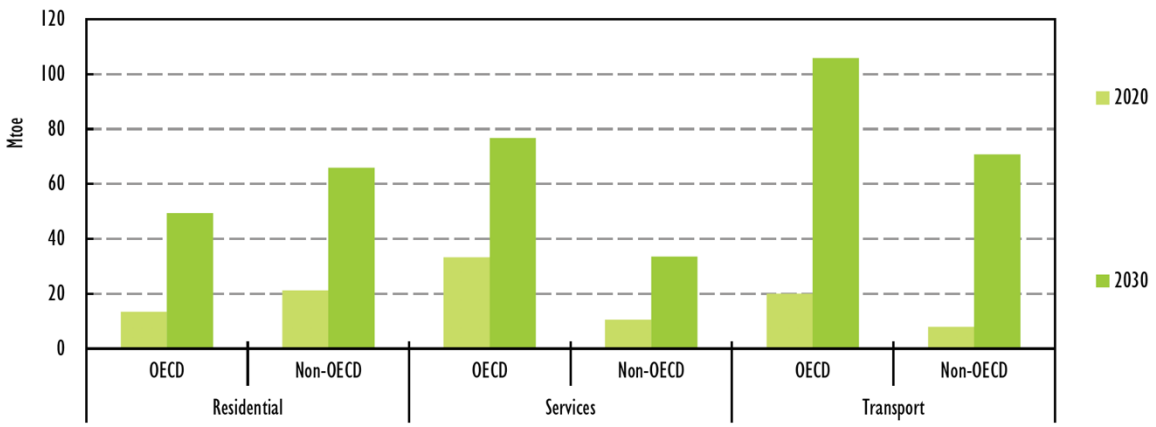

Figure 2. Energy savings in the NDC Scenario (IEA, 2016)

Efficiency improvements are needed across the energy sector:

- The global power sector is still dominated by fossil-fuel power plants that normally convert only about one-third of their energy inputs to electricity, while CHP plants allow better use of waste heat energy for local communities (domestic or industrial). In addition the conversion losses for non-thermal renewable energy such as hydro, wind or solar power are low and generally are not accounted for in energy balances (REN21 2017).

- The building sector accounts for around half of the world's electricity demand (IEA 2016b). Ageing and inefficient building stock and fragmented heating and cooling markets are the priority issues to be addressed in this sector.

- There is significant energy efficiency potential in the transport sector. Road transport accounts for 75% of transport energy use. Improvements in the global average fuel economy (fuel used per unit of distance) of light-duty vehicles averaged 1.5% per year for the decade 2005-2015, slowing gradually to 1.1% in 2015 (IEA and Global Fuel Economy Initiative 2016).

Policy makers around the world are facing many barriers preventing them for achieving progress and cutting energy consumption even further. These include decreasing commodity prices, a lack of knowledge and capacity both among policy makers and investors, energy subsidies regulatory barriers, and misplaced incentives across different stakeholders (Levine et al. 2007). These barriers need to be tackled in order to reach the 2°C target.

Recommendation: Energy efficiency should be at the core of actions to meet the commitments of the Paris agreement.

ENABLING INSTRUMENT: GREEN FINANCE

Leading organizations from the energy sector have clearly pointed out the outstanding amount of resources needed to invest in the transition to low carbon energy system. The World Energy Council has pointed to the urgency of aligning public and private understandings on importance of financial markets for the evolution of the energy sector under 2°C scenario. Already in 2014, the Council estimated accumulated investment requirements of US$53 trillion between 2015 and 2035 and rightly questioned whether the existing funding instruments would adequately allocate capital to the energy sector ventures. Two challenges are salient, firstly, a still lacking framework of financial instruments, and secondly, the bias towards conventional energy projects.

In recent time two instruments caught the attention of the markets as new means to stream capital into low carbon energy infrastructure, green bonds worldwide and Yield Co in the United States specifically. In both cases the underlying story is based on the opportunities offered by the outstanding amount of private resources available to the energy sector. Whether it is the UNFCCC sponsored US$100 billion pledge or private resources, the key will be the existence of appropriate financial instruments.

Green bonds are characterized for providing fixed income, raised to invest on climate or environmental friendly projects. Their use in developed and developing markets is rapidly growing, but under an

environment of disarticulated standards. In fact, the definition of what is suitable to be financed through a green bond from the perspective of a low-carbon energy system is one of the largest and most important tasks ahead to the industry.

Confronted with the early success of green bonds, Yield Co instruments disappointed investors because the markets were not fully aware of the nature of the risks of the instruments – risks associated not to the renewable energy projects but to the cost of capital needed to augmenting the portfolio. As the Climate Policy Initiative points out, it has been a great learning opportunity to identify the need and opportunity for instruments to manage more moderate yield but less risky portfolios based on project revenue, which seem to be a perfect match to low carbon infrastructure projects (Varadarajan et al. 2016). However, new instruments must be paired with an adequate understanding of risk profiles and market expectation.

These instruments will ease the barriers for capital to access infrastructure investment projects, but the capital availability will rather depend on a major shift on the investment priorities, especially from institutional investors, through the reallocation of resources that will follow the adequate disclosure of climate-related risk. After all, historically in a ratio of 5:1 against public financing and more than US$120 trillion held by institutional investors .

In recent encouraging developments, the Task force on Climate-related Financial Disclosures set up by the Financial Stability Board presented its recommendation on the adoption of appropriate standards for corporate disclosure of climate risk. However, if the energy sector at large do not commit to these reporting recommendations, their adoption will follow regulatory initiatives from proactive governments, which might not be optimal for the development of the sector.

Recommendation: Private sector needs to integrate climate change in its business strategy, carrying out a thorough assessment, informing on the level of exposure, and enhancing the disclosure level. Voluntary platforms to settle on plans on the appraisal of climate-related risks are good examples of the right steps the energy industry should take.

CONCLUSIONS

The Paris Agreement proposes to keep the increase in global average temperature to well below 2 °C above pre-industrial levels so that the share of fossil fuels would be reduced and the share of low carbon sources would be increased to more than half of the energy demand. ***Renewable energy and energy efficiency measures*** must play a major role, potentially able to account for 90% of required carbon reductions. Reducing climate change risks and seizing new opportunities can happen during this energy transition.

The life cycle assessment in terms of sustainability can have a significant impact for a low carbon economy. New business models perpetuate cradle to grave approaches that can be driven simply by reducing carbon footprint in terms of overcoming social risks. ***Electrification of the economy*** is encouraged in the power sector by reducing the direct use of fossil fuels that can lead to a massive emission cut in the energy sector. ***Energy demand response programs*** as well as energy storage for intermittent renewables are being implemented by some electric system planners and operators, balancing supply and demand. Such programs can lower the cost of electricity in wholesale markets, and in turn, may lead to lower retail rates.

Governments are responsible for managing a wide array of their own energy assets, from research and development efforts, resiliency of infrastructure and technology transfer. Carbon Pricing Mechanisms are playing, and could further play, a significant role in helping countries meet their greenhouse gas emission targets. On the whole, carbon pricing is one of the more efficient tools available to governments to incentivise a transition to a low carbon economy. As the renewable energy sector matures and grows, policies are increasingly being adapted to benefit shifting market conditions. Energy efficiency is the only energy resource possessed by all countries, and it will be at the core of actions to meet the commitments of the Paris Agreement. The financial system can have a great impact in the green transformation of our economies in order to combat the effect of climate change.

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