Asia-Pacific
Economic Cooperation

APEC

Green Finance Report

Unlocking the Urban Energy Transition

ENERGY WORKING GROUP

March 2023

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Foreword

APEC Sustainable Energy Center (APSEC) is pleased to present the *APEC Green Finance for Urban Energy Transition Report.* This report is destined on the one hand to the broader APEC Energy Working Group and its sub-groups, whose targeted readership is composed mainly of non-specialists of finance, on the other hand to urban planners of APEC cities wishing to get new insights about the road to carbon neutrality and the way to achieve it. Consequently, the report starts with exposing roadmaps towards carbon neutrality, identifies their financing gap and outlines the frameworks adopted by COP26 and by APEC designed to give guidance for the transition towards carbon neutrality. It then presents the two ways to increase the role of green finance, namely increasing returns and profitability of green investments, and de-risking green investments. Case examples underpin the theoretical arguments. The report then shows how different roles of cities can each contribute to attain local carbon neutrality.

The pathway towards carbon neutrality is a pathway towards prosperity, not towards austerity. The number of jobs created is a multiple of the number of jobs lost. But this transformation does not come without an initial investment in the amount of 4% to 5% of global GDP per year, which must be mobilized during the present decade. Green finance is needed to breach the financing gap. It should be directed to a greater extent towards less developed economies where the cost of setting up new infrastructures is lower, but risks are higher, which increases the cost of financing. De-risking mechanisms should overcome this obstacle. Cities can act in many ways in favour of carbon neutrality. In their different roles, they can help improving the local investment conditions.

This report is the third APEC report produced by APSEC and endorsed by the APEC Energy Working Group (EWG). In 2018, the EWG endorsed the APEC Sustainable Urban Development Report – From Models to Results. In 2021 the EWG endorsed the Integrated Urban Planning Report – Combining Disaster Resilience with Sustainability.

This series of reports is written with reference to the APEC High-Level Urbanization Forum having taken place in Ningbo in June 2016. This forum was the first large-scale high-level event under the APEC framework with a focus on urbanization. The Ningbo initiative that started at that occasion affirmed the importance of promoting sound, sustainable and people-oriented urbanization in APEC within the Asia-Pacific Urbanization Partnership that had been endorsed by APEC Economic Leaders in Beijing in November 2014.

APEC Sustainable Energy Center

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Specifically, we are grateful to the following experts and contributors:

Experts participating in the 6th APEC Workshop on Sustainable Cities organized by APEC Sustainable Energy Center as online event on 9 December 2021, comprising delegates from China, Indonesia, Japan, Malaysia and the Philippines.

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This report does not necessarily reflect the views or policies of the APEC Energy Working Group or individual APEC member economies. This report is to be interpreted as a scientific and analytic contribution. No APEC economy endorsing this report will be bound by any of its conclusions. The authored contributions of third parties do not necessarily reflect the views of these third parties.

We hope that this report will serve as a useful basis for analytical discussion both within and among APEC member economies for the enhancement of sustainable urban development.

Purposes, Key Findings and Recommendations

Purposes

- Outline roadmaps towards global carbon neutrality, estimate the corresponding financing gap and mention the UN and APEC political frameworks to address these issues
- Show how green finance can close the financing gap by improving returns and profitability of green investments and mitigating their risk
- Describe how cities can catalyse the energy transition by combining green finance with other economic instruments and use them according to the multiple roles of cities

Key Findings – Chapter 1

The 2015 Paris Climate Agreement fixes a maximum tolerance level for the admissible global warming to well below 2°C with efforts to keep it to 1.5°C above pre-industrial levels. The IEA Net Zero by 2050 Roadmap for the Global Energy Sector defines more than 400 milestones to attain the 1.5°C goal by 2050. Annual global energy investment should jump from 1% to 4.5% of global GDP in the next few years, which mostly should go to clean energy. The IEA pathway creates six times more jobs than are lost during the transformation, and adds 0.4% additional annual global GDP growth, accumulating by 2050 to an economy of the size of Japan to the globe. The IRENA World Energy Transition Outlook (WETO) 2021 also emphasizes the large number of jobs created during the transition. The share of renewable energy in total primary energy supply would rise from 14% in 2018 to 74% in 2050, at an annual growth rate of 1.87%, an eight-fold increase from recent years. Total global energy use would be nearly constant between 2018 and 2050, while economic activity nearly triples by 2050. APSEC calculates that if the post-2010 trend of reducing CO_2-intensity continues, APEC will be carbon neutral by 2050 and the world by 2057. Carbon neutrality is interpreted to mean gross annual per capita emissions of at least 1tCO_2, of which one third are from human physiological activity and two thirds from agricultural livestock. The Kaya identity gives a simple conceptual framework to monitor the key variables towards carbon neutrality. The bottom line of per capita energy use is determined by Decent Living Standards (DLS) which require 120W per capita in form of food energy and 380W per capita as non-food energy. With a capacity factor of renewable electricity dropping from today 30% to 20% in the long term, DLS requires installed renewable electricity capacity of 1900W per capita and additional food energy of 120W per capita. These two numbers define a “2000W-Society”. In 2020, installed capacity was at 362W/person at global average, and 561W/person for APEC. Continuation of the high growth rates of the period 2008 – 2020 will double installed capacity by 2030 for both, APEC and the world. APEC will attain the 1900W/person level in 2035, and the world in 2044.

The target of 0.7% ODA/GNI and 0.15 to 0.20% of ODA/GNI to least developed economies is but a small fraction of the 4.5% of the global GDP per year that must go to clean energy. The annual $1 to $1.5 trillion goal per year to finance infrastructures is a multiple too low, and the annual $100 billion goal specifically for clean energy and energy infrastructure is just 2% of the necessary amount. This is too little, even when considering that ODA should only be the catalyst or that it should only finance the creation of framework conditions. Through COVID-19, neither renewable capacity additions which attained an all-time high of 36% in 2020, nor the extension of electricity access, nor global internet connectivity, nor the growth of fixed

internet broadband subscriptions were stopped. By the end of the present decade the world might be fully interconnected. COVID-19 has caused a 30% decline in energy trade, increased public debt by more than 15% of global GDP, has seriously affected the education system, has caused a drop of FDI flows by more than a third; whereby flows to SDG7 (energy) and SDG11 (sustainable cities) were more than halved. COP26 has mobilized public pension funds ($52 trillion), sovereign wealth funds ($9.2 trillion) and insurances ($30 trillion) in sufficient order of magnitude to engineer carbon neutrality. It also approved the long-awaited articles on international carbon market mechanisms. In 2021, APEC Leaders have adopted the Aotearoa Plan of Action.

Key Findings – Chapter 2

Green finance is defined by the flows directed to green economy. Green taxonomies delimitate the green sector from other activities. The taxonomy of China (since 2015) includes only activities that are undoubtedly green so that green bonds can be issued. The taxonomy of the EU (since 2019) is based upon technical screening criteria that allow including a wider range of goods or services under certain conditions so that it can deliver sufficient information for mandatory disclosure of enterprises. Since its inception by the UN in 2004, ESG was implemented in form of six Principles of Responsible Investment (PRI). The volume of PRI implementing assets worldwide has grown to more than $120 trillion by 2021, a multiple of the annual investment gap to attain carbon neutrality. Six major ESG rating agencies show high disagreement in ESG ratings. Contrary to credit rating, underpinned by probability of default, ESG rating lacks a similar underpinning. Separating genuine ESG improvement from greenwashing remains a challenge. ESG could to some extent be underpinned by SDGs and resilience indicators.

Increasing the attractiveness (profitability/risk ratio) of green investments requires either increasing their profitability, or decreasing their risk, or both. Carbon pricing is the instrument of choice to increase green sector profitability by eliminating *the greatest market failure the world has ever seen* (Stern Report, 2007). Yet, incentive carbon taxes have not mushroomed. It has been impossible to design WTO-compatible border taxes to prevent carbon leakage. Furthermore, incentive carbon taxes should be levied in market segments where there are alternatives to fossil fuels. Boulder (Colorado) gives the example of a successful local carbon tax that generates green finance. Compared to subsidies on renewables which amount to 0.5% of global GDP, the world pays four times as high direct fossil fuel subsidies and twenty times as high indirect fossil subsidies. While APEC Leaders called in 2009 to phase out certain fossil fuel subsidies, IRENA proposed to diminish fossil fuel subsidies by one third, while half of the remaining fossil fuel subsidies ($300 billion annually) should be used as source of green finance for clean energy. The least cost option to attain carbon neutrality is the emissions trading system (ETS). ETS or black certificate trading is a high-tech mechanism. It generates green finance to the extent its proceeds flow to green projects. COP26 created new trading mechanisms replacing the earlier Kyoto Protocol ones. Cities receiving emissions targets are expected to participate in compliance markets. For all other cities, high integrity voluntary carbon markets become an instrument to contribute towards carbon neutrality. Energy attribute or green certificates allow trading green energy. COP26 has created the possibility to link green and black certificates in a single compliance market. It is now possible set more ambitious goals to reduce CO_2 or to increase the renewables share knowing that the costliest measures can be financed by the compliance market. Feed-in tariffs (FIT) are the most rapid way to increase renewables and hence a powerful source of green finance. Their problem is their

success. The too rapid growth of intermittent power sources has been a challenge for electricity grids. FIT used at local level can be an instrument of choice to increase the local renewables share. Power Purchase Agreements (PPA) are a generalization of FITs and can be combined with green certificates to increase the renewables share. For liberalized electricity markets, virtual PPA (vPPA) are the appropriate form. Public Private Partnerships (PPPs) are used by cities to fill funding gaps for green investments. Prerequisite for PPPs is, among others, the existence of a market for green infrastructure projects. Land Value Capture (LVC) is one of the most important instruments to finance Transit Oriented Development (TOD). It is analysed as a source of green finance to the extent that TOD, together with mixed zoning, diminishes energy consumption of daily commuting.

The overview of green financing instruments shows that green bonds, the most popular instrument, experience strong growth. Green loans are bilateral and much less in volume. Green equity is important as it does not create debt and helps in de-risking. Environmental insurance has a huge potential but requires a clear legislative basis. Credit guarantees are the indispensable way to de-risk investment flows to developing economies.

Credit Risk Guarantee schemes are the instrument of choice to improve the risk-return ratio of investments. Financed by a third party such as a government agency, they protect the lender against default of the green project owner who pays a guarantee fee similar to an insurance premium. The optimal amount of the guarantee fee should depend on the lender, the borrower and the general economic context. Commercial banks play an important role to develop green projects. Their instruments include a combination of green credit, green bonds, green leases, green trusts, green insurance and green wealth management. The example of the Construction Bank of China (CCB) and its activities and instruments is presented in the text. Green bonds have also been used to finance the energy efficiency renovation of super-tall buildings in China. The example of the Qingdao Haitian Center T2 Tower Building shows how green bonds have helped to overcome the finance gap to install ten new energy-efficient technologies. The increasing role of insurance for financing climate risks is shown by the example of Insurance Linked Securities and Catastrophe Bonds proposed by SwissRe. With the help of these new types of securities, which emerged after natural catastrophes of the early 1990s, it is possible to transfer tail risks which cannot be supported by a single company to the financial market which has much bigger capacity.

The Asian Development Bank (ADB) is one of the multilateral financial institutions that is active in financing carbon neutrality. It works primarily with governments but has also a strong arm for cooperation with the private sector. ADB is for certain cases a lender of last resort. ADB uses green finance to provide several categories of benefits to its credit takers. The cooperation takes different forms depending on the partner. ADB has also engaged itself in the Belt and Road initiative. The Asian Infrastructure Investment Bank (AIIB), created in 2016, has at present investments in 168 projects with an approved amount totalling USD 33 billion. Its sustainable energy strategy dates from 2017 and comprises improving energy access and security, energy efficiency, reduction of carbon intensity, management of local and regional pollution, catalysing private investment, and promoting regional connectivity. Energy comprises 34% of the bank's total financing. A cross-sectoral city strategy was added in 2018. AIIB has set a 50% target of climate financing against its total approved portfolio by 2025 and an earlier deadline of 1 July 2023 for its operations to be aligned with the goals of Paris Agreement. The Green Climate Fund GCF is the financing instrument of the Paris Climate Agreement. It has developed a strategy for cities attempting a paradigm shift. This is focusing

on the relationship between local and central government level, centralization and decentralization pressures, how cities can take demand side measures to improve their credit ratings, and supply side measures to mobilize private finance. GCF works with grants, equity, guarantees and concessional loans. De-risking is one of the prime tasks. For cities, there are 8 priority areas. Megacities need to be retrofitted, whereas small and medium size cities need to decouple new infrastructure from emissions. The Shandong Green Development Fund is an example of the Beijing-Tianjin-Hebei area. The GCF engagement of $1.5 billion will leverage $12 billion private funds, with a catalytic factor of 8, and bring about emissions peak in 2027 – three years ahead of schedule. The International Finance Corporation IFC is the World Bank's private sector support mechanism. $33 billion green loans are outstanding, of which $695 million have been granted in fiscal year 2020. The bulk goes to renewable energy. Energy efficiency, mitigation and more recently, adaptation have been added. In 2019/20 the IFC granted a first-time green loan to Mexico for renewable energy. Green loans to China include loans for solar power, green banking and agribusiness/forestry.

Key Findings – Chapter 3

The example of Metro Manila of the Philippines is ranked 7th among the vulnerable urban areas to climate change. A severe problem is the water management during the monsoon months, when around 80% of annual rainfall occurs. The pumping infrastructure is old and not capable to withstand the requirements of recent rainfalls. The entire region is vulnerable to flooding with the coastal areas of Metro Manila registering the highest vulnerability. Metro Manila Flood Management Project is designed to resolve the problems caused by foods. It comprises modernization of pumping stations and drainage areas, minimizing solid waste in the waterways, participatory housing and resettlement, and project management and coordination. The first certified climate bond has been issued in the Philippines in 2016 for a geothermal power station. Today, the Philippines is the third largest green bond issuer in ASEAN. China has made important steps towards the reconversion of industrial parks to Eco-Industrial Parks (EIP). In 2021, UNIDO, World Bank and GIZ have released a set of standardised approaches for implementation of EIP. Focus should be on clean energy, wastewater treatment and waste heat. Asian Development Bank invested in its first eco-industrial park (EIP) waste-to-energy project in Shanghai via a $100 million loan. Another project is the Wuzhou Circular Economy Industrial Park located in Longxu, Wuzhou city, Guangxi Zhuang region. In 2020, the World Bank approved an investment of $200 million for the Jiangxi Eco-Industrial Park. The World Bank is also providing support to the Fuzhou New Industrial Zone, which will provide co-benefits in terms of GHG emission, pollution and urban flood risk reduction. The problems of a medium-size town are illustrated by Tomohon city, Indonesia. The focus lies on developing mass transportation systems to decrease road congestions. An example of a catalytic effect related to urban energy transition is given by Shanghai. A study shows that an energy efficiency and emissions reduction fund plays a catalytic role in enabling coordination and collaboration across different government departments on cross-cutting policy domains.

Looking at the different roles of cities to facilitate the energy transition, the role of policy maker and regulator is essential. Since the adoption of Local Agenda 21 in Rio in 1992, cities have been the focus for shaping and implementing local sustainability. The Global Climate Alliance is now the forum where more than 11'000 cities and other stakeholders communicate their policies and exchange experience. In the past years some cities have started adding carbon neutrality as a distinct objective. 13 APEC cities have become members of the Carbon Neutral Cities Alliance (CNCA). In the role of land planners, cities can inspire themselves from the Five Principles of Sustainable Neighbourhood Planning adopted in 2015 by UNHABITAT

concretizing key indicators for transit-oriented development (TOD). Waste management and wastewater treatment yield energetic by-products which cities can use. An important role of cities is the one as infrastructure managers. The modern list of infrastructures includes protective natural infrastructures. PPP can generate green finance. Cities are procurers and consumers, and as such are key players to drive the technologies used to produce energy. Cities are also data producers and should collect data for SDG implementation. Energy and climate data at local level are still rare.

Recommendations

This report outlines roadmaps towards global carbon neutrality, shows how green finance can close the financing gap, and describes how cities can catalyse the energy transition according to their multiple roles.

Based on this report, the following specific recommendations are made.

APEC should set the goal to double the per capita installed renewable electricity capacity by 2030 and reach the 2000W/person threshold in 2035. An agreement with IRENA might be appropriate for realizing this goal.

APEC should consider setting carbon-neutrality as a collective long-term goal to be attained by 2050 for developed economies and by 2060 for developing economies.

APEC should consider redefining the principle of phasing out fossil fuel subsidies decided in 2009. APEC should consider formulating a principle stating that part of fossil fuel subsidies should be phased out, whereas another part should be redirected towards renewable energies, especially for poor and vulnerable populations.

APEC should consider setting up mechanisms to increase both, public and private green investment, especially in developing economies. Green investment should comprise more equity than debt. APEC cities should be active in shaping the local regulatory environment so that green equity develops easier on their territory.

APEC should explore whether APEC cities can set minimum values for the catalytic factor of public investment in the green economy in their cities.

Specifically, APEC should consider the feasibility of setting up, possibly with the participation of APEC cities, an APEC-wide de-risking guarantee scheme for renewable energy.

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1. The Narrow Path Towards Carbon Neutrality

The 2015 Paris Climate Agreement fixes a maximum tolerance level for the admissible global warming to well below 2°C with efforts to keep it to 1.5°C above pre-industrial levels. The IEA Net Zero by 2050 Roadmap for the Global Energy Sector defines more than 400 milestones to attain the 1.5°C goal by 2050. Annual global energy investment should jump from 1% to 4.5% of global GDP in the next few years, which mostly should go to clean energy. The IEA pathway creates six times more jobs than are lost during the transformation, and adds 0.4% additional annual global GDP growth, accumulating by 2050 to an economy of the size of Japan to the globe. The IRENA World Energy Transition Outlook (WETO) 2021 also emphasizes the large number of jobs created during the transition. The share of renewable energy in total primary energy supply would rise from 14% in 2018 to 74% in 2050, at an annual growth rate of 1.87%, an eight-fold increase from recent years. Total global energy use would be nearly constant between 2018 and 2050, while economic activity nearly triples by 2050. APSEC calculates that if the post-2010 trend of reducing CO_2-intensity continues, APEC will be carbon neutral by 2050 and the world by 2057. Carbon neutrality is interpreted to mean gross annual per capita emissions of at least 1tCO_2, of which one third are from human physiological activity and two thirds from agricultural livestock. The Kaya identity gives a simple conceptual framework to monitor the key variables towards carbon neutrality. The bottom line of per capita energy use is determined by Decent Living Standards (DLS) which require 120W per capita in form of food energy and 380W per capita as non-food energy. With a capacity factor of renewable electricity dropping from today 30% to 20% in the long term, DLS requires installed renewable electricity capacity of 1900W per capita and additional food energy of 120W per capita. These two numbers define a “2000W-Society”. In 2020, installed capacity was at 362W/person at global average, and 561W/person for APEC. Continuation of the high growth rates of the period 2008 – 2020 will double installed capacity by 2030 for both, APEC and the world. APEC will attain the 1900W/person level in 2035, and the world in 2044.

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1.1. Roadmaps towards Carbon Neutrality

1.1.1. The IEA Net Zero by 2050 Roadmap for the Global Energy Sector

Carbon neutrality and climate neutrality have become widely discussed long term objectives. The COVID-19 pandemic may have accelerated the general awareness that global disasters can happen and need to be addressed. Since the adoption of the UN Climate Convention in 1992, GHG emissions have increased by 60%, creating an ever-larger likelihood that climate change causes associated climate disasters. The scientific community has been aware for some time that there is such a thing called *cumulative global GHG budget*, and that industrial development at the speed it happens now is consuming this budget much more rapidly than this budget is regenerating itself. The 2015 Paris Climate Agreement neither mentions carbon neutrality nor climate neutrality, but rather uses the approach to set a maximum tolerance level for the admissible global warming, leaving it to policymakers to define how to attain it. The Paris Agreement requires *holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels*[1].

The IPCC glossary to the IPCC special report on the impacts of global warming of 1.5°C[2] defines the terms of carbon and GHG neutralities as well as the associated net zero emissions:

Carbon neutrality: *Condition in which anthropogenic carbon dioxide (CO_2) emissions associated with a subject are balanced by anthropogenic CO_2 removals. […] carbon neutrality generally includes emissions and removals within and beyond the direct control or territorial responsibility of the reporting entity.*

Net zero CO_2 emissions: *At a global scale, the terms carbon neutrality and net zero CO2 emissions are equivalent. At sub-global scales, net zero CO_2 emissions is generally applied to missions and removals under direct control or territorial responsibility of the reporting entity.*

Greenhouse gas neutrality: *Condition in which metric-weighted anthropogenic greenhouse gas (GHG) emissions associated with a subject are balanced by metric-weighted anthropogenic GHG removals. […] GHG neutrality generally includes emissions and removals within and beyond the direct control or territorial responsibility of the reporting entity*.

Net zero greenhouse gas emissions: *At a global scale, the terms greenhouse gas neutrality and net zero greenhouse gas emissions are equivalent. At sub-global scales, net zero GHG emissions is generally applied to emissions and removals under direct control or territorial responsibility of the reporting entity.*

For science, the IPCC has extensively addressed this issue in its Special Report on Global Warming of 1.5°C (SR15), the first report of the Sixth Assessment Cycle, released in October 2018[3]: *In model pathways with no or limited overshoot of 1.5°C, global net anthropogenic CO_2 emissions decline by about 45% from 2010 levels by 2030 (40–60% interquartile range), reaching net zero around 2050 (2045–2055 interquartile range). For limiting global warming to below 2°C (66% probability), CO_2, emissions are projected to decline by about 25% by 2030 in most pathways (10–30% interquartile range) and reach net zero around 2070 (2065–2080 interquartile range)*.

Outside the scientific discussion the explicit probability figures are sometimes left out, implying other implicit probabilities. This may give slightly different time ranges as the figure below shows but the sequence in time remains the same. For the 1.5°C scenario, carbon

neutrality should arrive around 2050 whereas climate neutrality should be realized around 2065. If the 2°C scenario is chosen, carbon neutrality should arrive around 2075 and climate neutrality towards the end of the century. In all cases, the focus at present is on limiting CO_2 emissions, the biggest contributor to global warming.

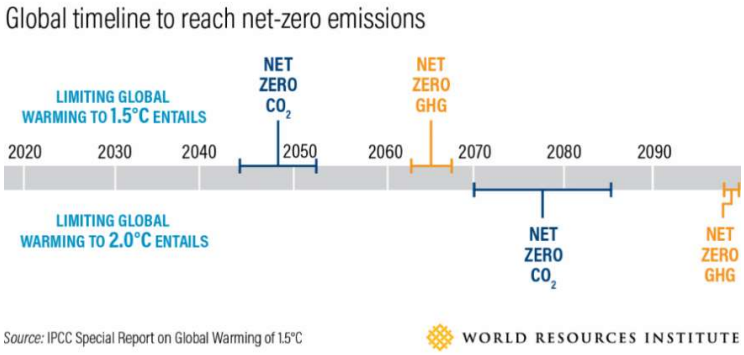

Figure 1: Global timeline to reach net-zero emissions

Source: World Resources Institute[4]

Note also that carbon neutrality does not include methane and is, therefore, less broad than energy related emissions. Both carbon neutrality and climate neutrality designate the net emissions, i.e., the gross emissions minus the carbon or GHG removal from the atmosphere, respectively. If carbon or other GHG can be removed faster from the atmosphere, the dates stated above can happen earlier. Most technical solutions to remove carbon from the atmosphere are still very expensive.

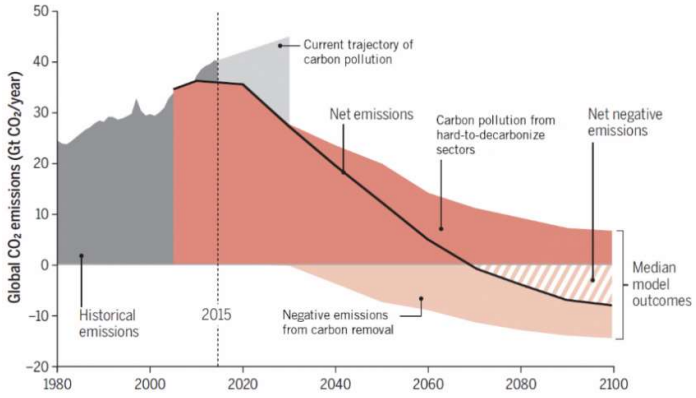

Figure 2: Carbon emissions and carbon removal

Source: Energycentral.com[5]

Several important contributions to the analysis of net zero have been elaborated during the year 2021. A noteworthy contribution came from the International Energy Agency (IEA).

In the *Net Zero by 2050 – A Roadmap for the Global Energy Sector*[6], the IEA, in cooperation with the International Monetary Fund (IMF) and the International Institute of Applied Systems Analysis (IIASA) and more than 100 peer-reviewers, for the first time ever sets out a global Net Zero 2050 Roadmap. Deviating from earlier practice, the IEA reports are now available in full online and free of charge, accompanied by all the data and the figures. In earlier reports, the IEA compared a Stated Policies Scenario (STEPS) which basically

stabilizes emissions at current levels with a Sustainable Development Scenario (SDS) which halves emissions by 2040. Both are clearly less transformative than the Net Zero by 2050 Roadmap. In the 2020 World Energy Outlook (WEO) and the 2020 Energy Technology Perspectives (ETP), the IEA has already made special cases and analysis on 1.5-degree future, to understand modelling capabilities and data, but did not yield a global 2050 scenario. The reasons for having focused on a more transformative scenario are economic. The Net Zero by 2050 Roadmap will create six times more jobs than will be lost during the transformation and allow for a net global GDP increase of 0.4% per year up to 2050, adding an economy of the size of Japan to the world by 2050. The Net Zero by 2050 Roadmap is, therefore, a road towards prosperity and not a road towards austerity. But despite being a road towards prosperity, it does not come without policy measures. World energy investment needs to increase from currently 2 trillion USD to 5 trillion USD annually by 2030, of which 4 trillion USD need to be made to clean energy. New technologies such as advanced battery, hydrogen and direct capture need to be pushed forward and put on the market by 2030, allowing the need for fossil fuels to be reduced substantially. For new technologies to be developed, international cooperation is essential. To leave no one behind, special care needs to be taken for fossil fuel dependent regions e.g., by installing, where feasible, wind or solar farms on closing oil and gas fields. Overall, there is still a narrow pathway to remain within the 1.5°C limit. It is worthwhile to look at this roadmap in greater detail as it is highly relevant to the energy sector.

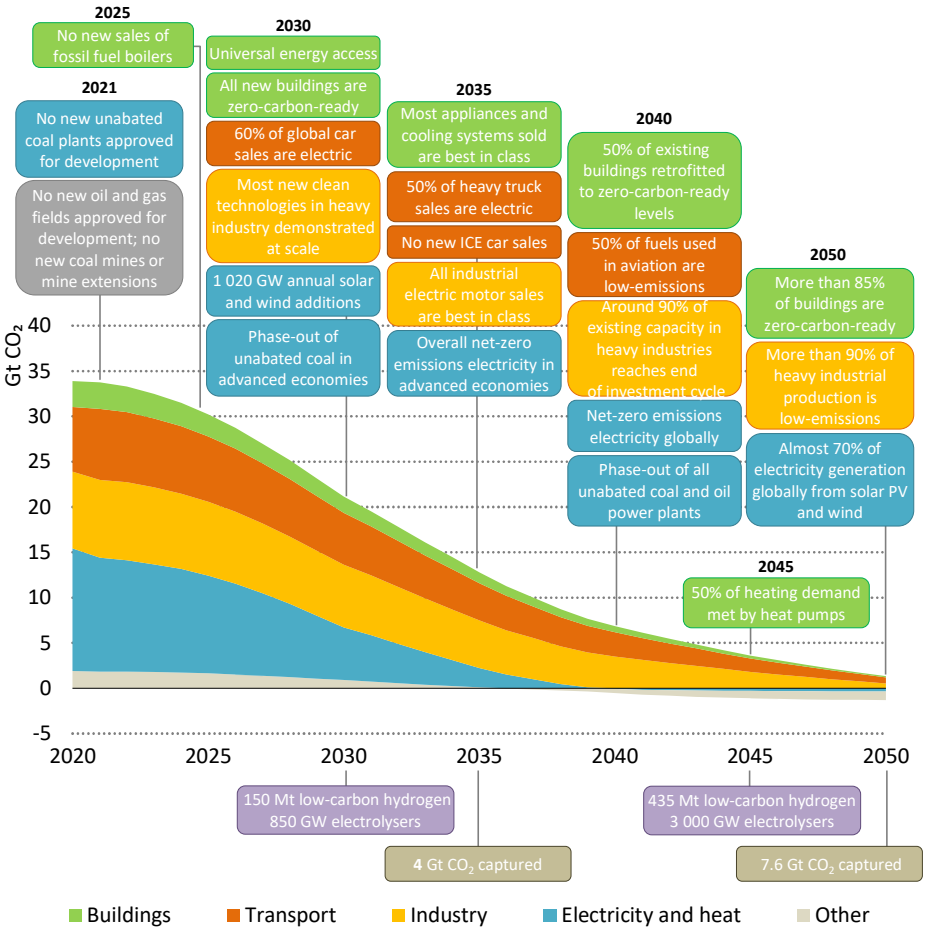

Figure 3: Key milestones in the pathway towards net zero

Source: International Energy Agency[7]

The roadmap contains more than 400 milestones of which the most important ones are shown in the figure.

- From today, no need for new fossil fuel supply investments, no need for any unabated new coal fired plants
- By 2030, all existing market-ready technologies (e.g., EVs, LED lights, public transportation) are fully rolled out and all prototypes of new technologies (e.g., advanced battery, hydrogen and direct capture) are market-ready
- By 2030, all new buildings are zero-carbon ready
- By 2035, no new sales of internal combustion engine cars
- By 2040 the global power system is carbon free in net terms

For the net zero emissions pathway, the current decade is the turning point. The most important driver is energy investment. The jump from 2.2 trillion USD (or 2.5% global GDP) to 5 trillion USD (or 4.5 % global GDP) takes place only once, during the present decade, and overall energy investment will then be kept at a comparatively higher level until 2050, but due to economic growth its share in global GDP will fall back to 2.5% by 2050. 80% of this investment goes to clean energy by 2030. Most of the investment is spent on electricity generation, networks, and electric end-user equipment.

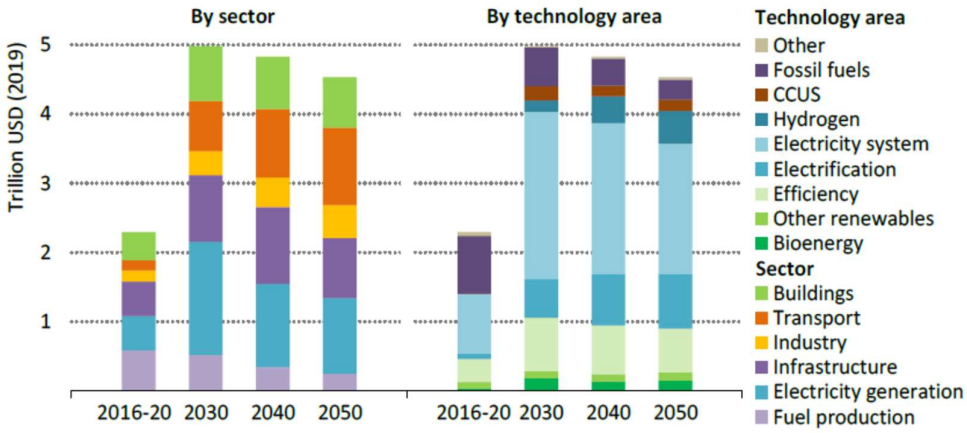

Figure 4: Annual Average Capital Investments (all energy) by sector and by technology area

Source: International Energy Agency[8]

During the current decade, the key technologies will have to leapfrog in spectacular ways. Capacity addition for solar and wind to multiply by a factor 4, global electric car sales by a factor 18, and energy intensity of GDP to diminish by 4% per year. For comparison, the aspirational APEC energy intensity goal provides for diminishing aggregate energy intensity by 45% from 2005 to 2035[9], i.e., a 1.5% linear decrease per year. The corresponding SDG target 7.3 reads[10]: “By 2030, double the global rate of improvement in energy efficiency”. During the base decade 2000 to 2010 chosen by the monitoring agencies, the improvement was 1.3% per year at global level. A doubling should be 2.6% per year[11]. Empirical data show an annual improvement of 1.7% per year since 2015[12].

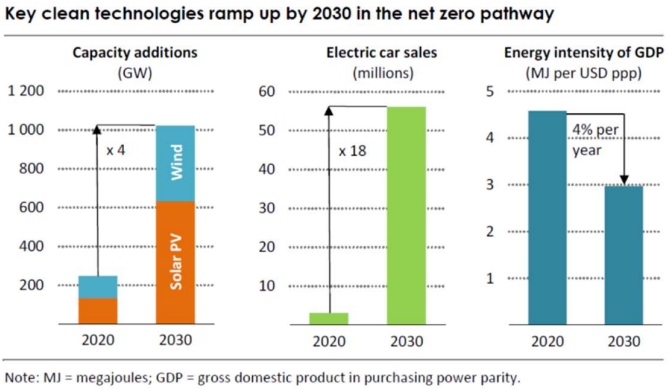

Figure 5: Key clean technologies ramp up by 2030 in the net zero pathway

Source: International Energy Agency[13]

The 4% energy intensity improvement of the net zero pathway for 2021 – 2030 result from the need to catch up the under-achievement of the years 2015 – 2021 to attain the original objective set by SDG7.3. Most of the improvement of energy intensity can happen through a few key factors such as switch to electric vehicles for transport, improvements in efficiency across industrial sectors and stringent building energy codes for both new and existing buildings, including the electrification of space heating in buildings by heat pumps.

Looking at the period 2030 – 2050 and distinguishing pathways of four key sectors electricity, transport, industry and buildings, electricity is expected to be the fastest to decarbonize as it will move from the highest share of CO_2 emissions to zero by 2040 and thereafter to negative contribution with direct air capture with carbon capture (DACCS). Other sectors such as bioenergy with carbon capture and storage (BECCS) will be able to show a negative emissions contribution by 2035 already. Both, DACCS and BECCS are ways to capture and permanently store CO_2.

Transport and industry diminish their emissions along similar pathways. The slowest to decarbonize is the buildings sector due to slow renovation rates. It starts, however, from a relatively lower emissions share than the other sectors. By 2050 these four sectors should all be carbon neutral.

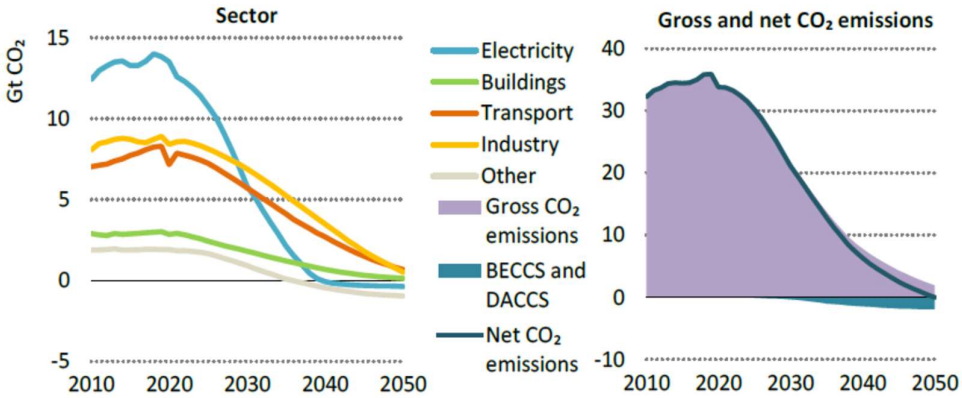

Figure 6: Sector specific pathways of the net zero emissions scenario

Source: International Energy Agency[14]

The IEA is not the only international organization having elaborated net zero emission (NZE) scenarios. The IPCC has also made many similar scenarios. Comparing the models of the two organizations for 2050 shows that the IEA NZE uses in general low levels of those technologies which are still in early development stage such as carbon capture, use and storage (CCUS) and energy-related carbon direct removal (CDR) which includes CO_2 captured through bioenergy with CCUS and direct air capture with CCUS and put into permanent storage. It also uses only 100 EJ of bioenergy in total energy supply (TES), two to three times less than IPCC scenarios. In NZE, energy efficiency manages to lower total final consumption (TFC) to 340 EJ in 2050, compared to 410 EJ in 2020, a diminution of 17% in 30 years or about half a percent per year. This is a greater role for energy efficiency than many IPCC scenarios. The IEA NZE also counts more on hydrogen (33 EJ in 2050) compared to most IPCC scenarios. Finally, the IEA NZE counts on wind and solar to provide for 70% of electricity production in 2050, more than most IPCC scenarios.

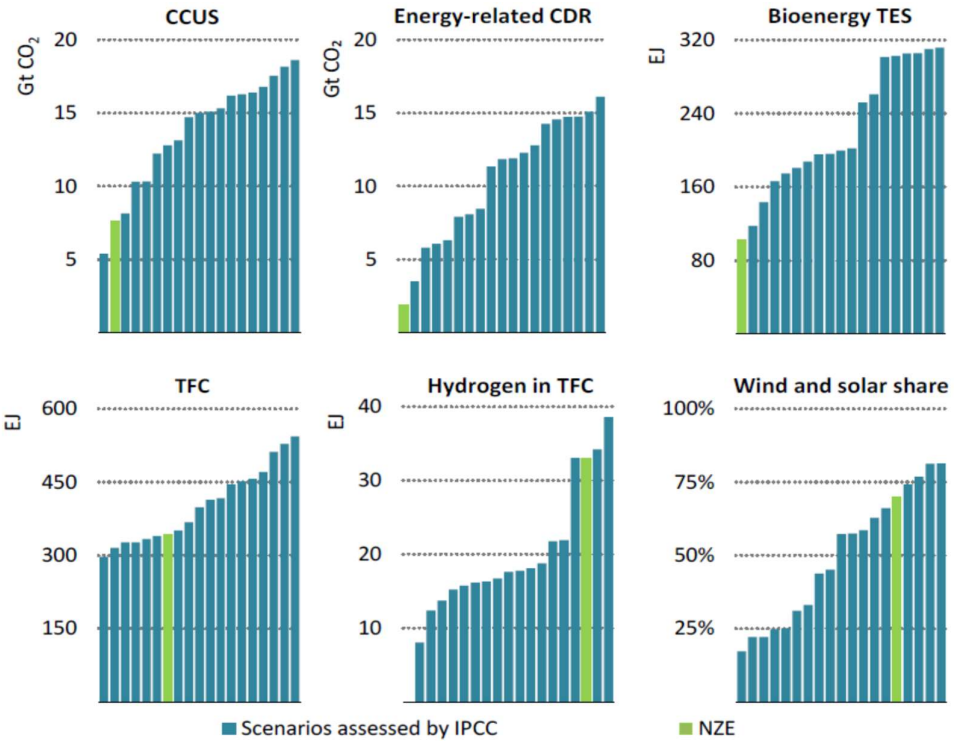

Figure 7: Comparison between 18 IPCC scenarios and IEA-NZE

Source: International Energy Agency[15]

As part of its sixth assessment report, the IPCC recently published the reports of its three working groups (WG I, II, and III):

- The Physical Science Basis of Climate Change in August 2021(WGI contribution)
- Impacts, Adaptation and Vulnerability in February 2022 (WGII contribution)
- Mitigation of Climate Change in April 2022 (WGIII contribution)
- Synthesis Report (expected in October 2022)

The Mitigation of Climate Change report of April 2022 has been released almost a year after the IEA Net Zero by 2050 Roadmap. It quotes specific IEA reports up to the 2021 World Energy Outlook published in October 2021 but does not contain any reference to the IEA Net Zero by 2050 Roadmap. Such reference can be found in the methodological Annex III[16].

Given the critical role of investment and financing, the IEA also released a report on Financing Clean Energy Transitions in Emerging and Developing Economies[17]. This report describes 50 case studies in economies that make up more than two thirds of the world population and 90% of global emissions but receive only 150 billon USD or 20% of global clean energy investment. Yet, emissions reduction cost in these economies is only about half as high and requires only half the investment as in developed economies. Clean energy investment in these economies should be multiplied by a factor seven to reach 1 trillion USD per year.

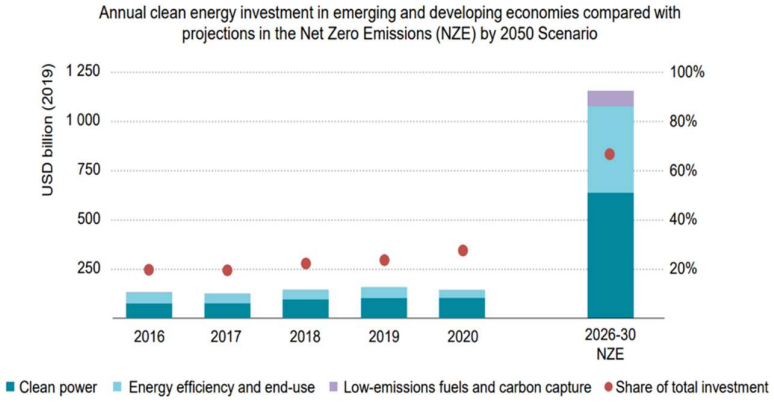

Figure 8: Annual clean energy investment in emerging and developing economies

Source: International Energy Agency[18]

A problem to be resolved arises from the fact that financing cost in these economies is up to seven times the financing cost in developed economies. The reason for this gap is the higher interest rates and higher risk premium due to uncertainty that prevails in these economies. Emerging and developing economies trying to diminish the risk premium should create a regulatory environment that improves long-term predictability of their economies and their governance.

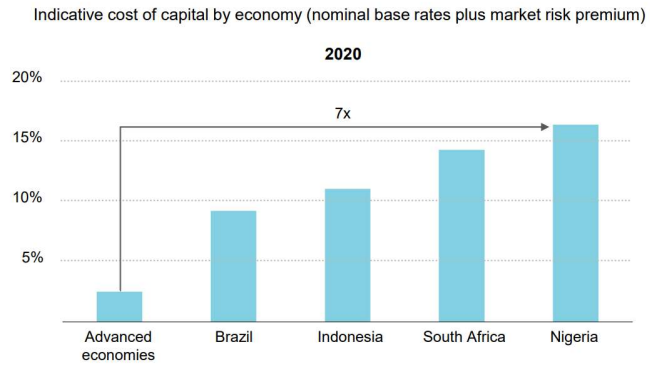

Figure 9: Indicative cost of capital by economy

Source: International Energy Agency[19]

Concerning the structure of finance, more than three quarters of finance for clean energy originates from the private sector and only one quarter from the public sector. For traditional energy the share of private finance is less than 60%. Also, clean energy relies for more than half its finance needs on debt, whereas equity provides less than half its finance. For traditional energy, the share of equity is greater than the share of debt. These two figures show that to enhance clean energy investment, the public sector could engage more than it currently does,

and that it could provide more equity than current equity levels. Cities and municipalities as lowest public sector level could possibly play a key role to change this.

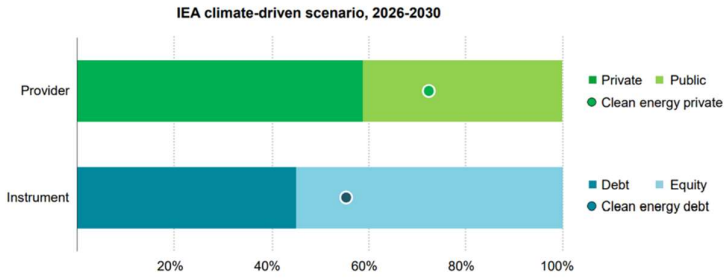

Figure 10: Capital origin and structure of the energy and clean energy sectors

Source: International Energy Agency[20]

Structural change is marking the pathway towards net zero. This can best be seen by the relative decrease of the oil or fossil energy sector and the corresponding rise of a cleantech sector comprising industrial activities that are related to renewable electricity and fuel cells. Electricity storage will be a dominant part of the cleantech sector.

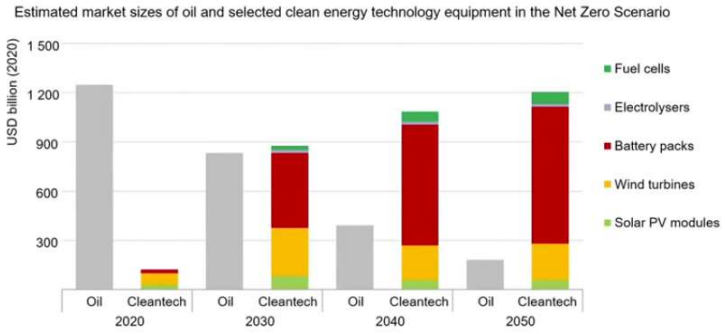

Figure 11: The decline of fossil industry and the rise of the cleantech industry

Source: International Energy Agency[21]

1.1.2. IRENA World Energy Transitions Outlook

Authored by Walter J. Sanchez and Ricardo Gorini, IRENA

IRENA's World Energy Transition Outlook (WETO, 2021)[22] describes a transformation of the energy sector aligned with the climate ambition to limit global average temperature increase by the end of the present century to 1.5°C.

The WETO (2021) outlines a set of energy transition trends. It considers the core drivers of an energy transition by outlining CO_2 emission pathways. This approach underlines technology avenues and measures that are prone to achieve emission mitigation goals between today towards 2050. This is inherently linked to (re-)allocation of investments and creating new ones to construct a green technological landscape able to accomplish an energy transition that is sustainable, just and inclusive.

Full decarbonisation of the energy sector as in the 1.5°C Scenario is challenging, yet feasible with massive ramp-up of efforts on multiple fronts. Two core lines of action can be highlighted in the analyses from a technical perspective.

First, the analysis indicates that electrification and energy efficiency to be the main decarbonisation drivers, mainly enabled by renewables, green hydrogen and sustainable biomass. By 2050, renewable energy can supply 74% of the total global energy demand and along with energy efficiency contribute to over 90% of the solutions to CO_2 emissions reduction that is needed to achieve an energy system in line with the 1.5°C Scenario.

Secondly, in the 1.5°C Scenario, the rate of energy intensity improvement needs to increase nearly two and a half times from historical average of 1.2% to 2.9% per year. This implies the deployment of energy efficiency technologies and measures such as more efficient boilers, air conditions, motors, appliances and even changes in customer's behaviour. The combination of renewable energy and electrification makes up to 1 pp per year followed by improvement of technical efficiency in the energy sector which can contribute about 0.65 pp per year of the improvement and the remaining improvements can be achieved from structural and behavioural changes including circular economy practices.

This double axis of the energy transition is not an easy task to accomplish, but not impossible. The twofold tenet of the WETO (2021) underlines that the energy transition relies heavily on the deployment of renewables and efficiency, which require investment and policymaking along with its implementation. This will not only generate gains in terms of clean and sustainable energy patterns, but it will trigger a net of socioeconomic benefits in terms of job creation by around 20 million additional direct and indirect jobs in 2050 in the renewable energy, energy efficiency and grid enhancement and flexibility sector.

Of the 20 million for the 1.5°C Scenario, solar jobs represent the largest share: 77% are PV, 15% solar water heaters (SWHs) and 8% concentrating solar power. Solar PV is the single-largest source of jobs in renewables. Bioenergy comprising all forms of biomass is the second-largest contributor given its high labour intensity for biofuels supply. By 2050 bioenergy employs 14 million people in the 1.5°C Scenario. Wind turbine blades are labour intensive to manufacture, but other parts of turbines are less so. Installation resembles the labour intensity of other large construction heavy infrastructure works. In the 1.5°C Scenario 5.6 million jobs are created by the wind industry. Hydropower is one of the oldest renewable energy sources and has grown much less in recent years than other renewables such as wind and solar. Altogether, jobs in hydropower are expected to remain stable at around 3.5 million across the transition.

That having been said, to assure a climate safe 1.5°C future along with its socioeconomic benefits, requires a financial muscle to lift technological expectations into palpable solutions. According to WETO (2021) an estimated additional energy system investment of USD 33 trillion needs to be settled in place on top of what has been planned over next 30 years. This investment in the energy transition not only reduces climate risks and harms, but it reduces externalities from lower air pollution. The overall benefit of the energy transition is valued at between 2 USD to 5.5 USD saved for every additional 1 USD spent.

Taking these figures into consideration, the question is, if the current line of action at global and regional levels is on track to accomplish the transformational quest that is necessary to harvest the benefits and gains of the energy transition. The WETO (2021) highlights that investment in energy transition technologies have reached an all-time high-level investment of USD 524 billion. However, these efforts need to be put into perspective. Among the energy transition technologies, renewable energy technologies dominated these investment flows,

though their share decreased over time from almost 90% in 2005-2009 to 70% in 2016-2020 as other energy transition technologies attracted increasing volumes of capital. In addition, investments in energy efficiency averaged just above USD 250 billion during 2014-2019 (IEA, 2020a)[23].

Despite a predominant fossil fuel-based energy sector, the current momentum in the renewable energy sector is noteworthy, as it has been largely noted that costs of renewable energy have continued to decline. Increasingly, solar PV and wind are the cheapest sources of green and clean electricity in many markets. Among newly commissioned projects, the global weighted average levelized cost of energy (LCOE) of utility-scale solar PV fell by 85% between 2010 and 2020, from USD 0.381/kilowatt hour (kWh) to USD 0.057/kWh for electricity from onshore wind cost have fallen by 56%, from USD 0.089/kWh to USD 0.039/kWh[24]. IRENA analysis estimates that by 2030, renewables technologies currently in commercial use will be cost-competitive with fossil-fuels in many parts of the world, and even undercut them significantly in many cases. The decade 2010 to 2020 saw renewable power generation becoming the default economic choice for new capacity. In that period, the competitiveness of solar (concentrating solar power, utility scale solar photovoltaic) and offshore wind all joined onshore wind in the same range of costs as for new capacity fired by fossil fuels, calculated without financial support. The trend is not only one of renewables competing with fossil fuels, but significantly undercutting them, when new electricity generation capacity is required. (IRENA, June 2021).

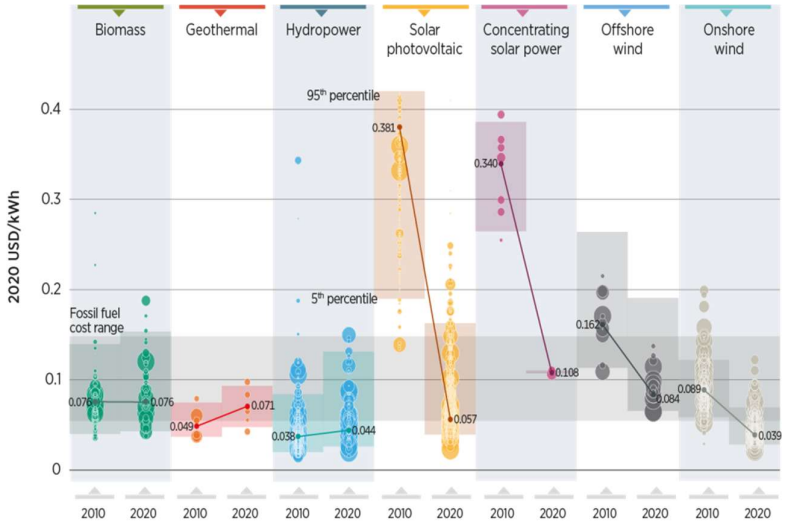

Figure 12: Renewables are increasingly the lowest-cost sources of electricity in many markets

Source: IRENA

According to the narrative of the WETO (2021) a climate safe future in 1.5°C Scenario will need to heavily invest in renewable energy technologies and energy efficiency to decarbonise current energy systems. To comprehend the scope of such a task, the main technology avenues need to be further understood in order to be able to earmark the main components where investments are necessary to achieve a 1.5°C Scenario.

Technology avenues in the energy transition

The WETO (2021) outlines that renewables, along with electrification and energy efficiency, are the main pillars of the energy transition. This predicament of the global energy transition features the synergy of two important actions in the energy sector: (1) the increasing use of low-cost renewable power technologies and (2) the wider adoption of electricity to power end-

use applications in transport and heat. These two options together with energy efficiency and savings create a scope of action that is straightforward: technologies and solutions that foment electrification and efficiency have an advantage position in the energy transition.

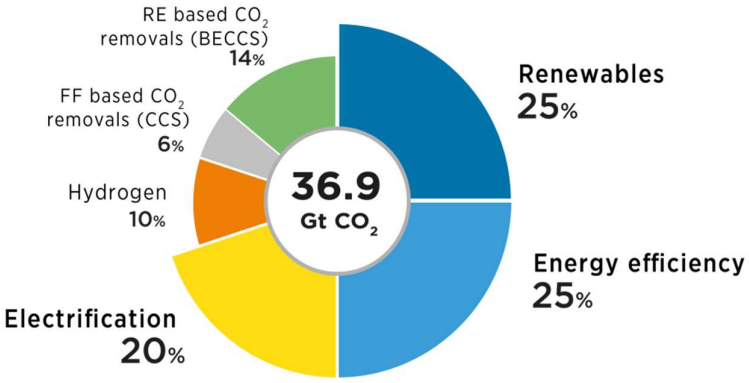

Figure 13: Renewables, efficiency and electrification dominate energy transition

Source: IRENA

Electrification allows for the use of carbon-free electricity in place of fossil fuels in end-use applications, and significantly improves the overall efficiency of energy service supply. Electric vehicles, for instance, are more efficient than internal combustion engines. For instance, hydropower, solar or wind generation, as well, is more efficient than fossil fuel, even natural gas generation. And within this rationale, it is also important that reductions in energy intensity are accelerated.

According to WETO (2021) the evolution of emissions phaseouts of coal and oil is achievable, if electrification with green and clean technologies and measures are deployed and implemented in the energy sector. The share of renewable energy in total primary energy supply would rise from 14% in 2018 to 74% in 2050. This is equivalent to an average annual growth rate of 1.87%, an eight-fold increase from recent years. At the same time the fossil fuel share would drop from 86% in 2018 to 26% by 2050 and total global energy use would be nearly constant between 2018 and 2050 while economic activity nearly triples.

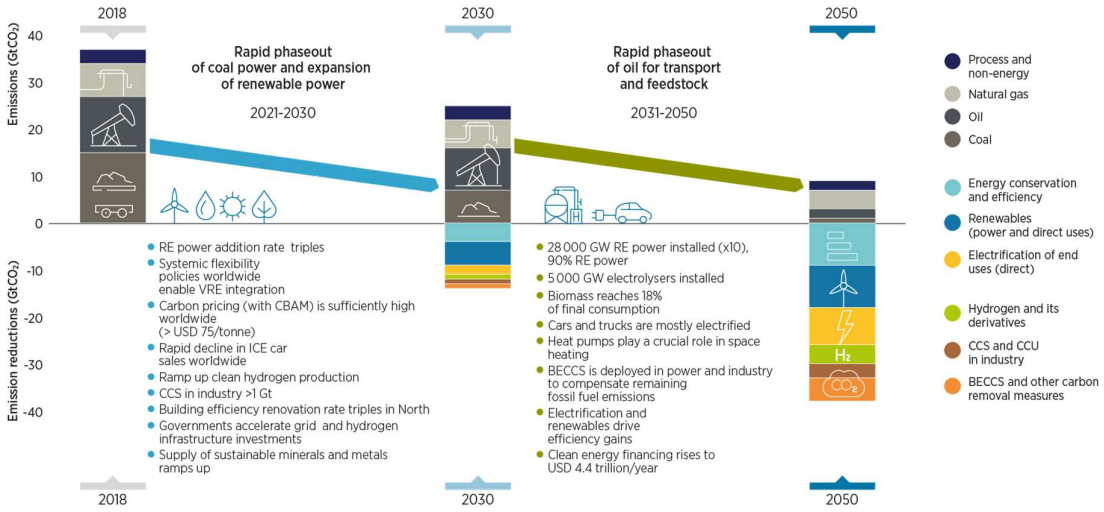

Figure 14: Phaseouts of carbon emissions from coal and oil, 2021-2050

Source: IRENA

The combination of the large-scale adoption of renewable energy technologies with high levels of electrification result in the largest increase in the rate of energy intensity improvement. Just under 18% of the improvement (0.3 pp per year) comes from the use of renewable energy technologies such as solar, wind and hydro to supply energy for electricity and heat, as well as a shift from traditional uses of bioenergy to modern forms of renewable energy. The largest improvement, making up over 40% (0.7 pp per year), comes from electrification, such as electric vehicles in road transport and heat pumps for heating and cooling applications.

In total, the combination of renewable energy and electrification makes up almost 60% of the improvement needed to achieve the scenario's energy intensity goal. It is relevant to notice that an important contribution will also come from structural and behavioural changes providing almost 10% of the needed efficiency improvement (0.15 pp per year).

The narrative of the WETO (2021) adds to the predicament of electrification and efficiency another key element: to foment the application of the principles of a circular economy. This will play an increasingly important role in forthcoming decades, not only furthering reductions in energy consumption, but increasing the efficiency of resource use, as well as improvements in material efficiency in industry due to innovations.

The WETO (2021) is clear on what path to follow for a sustainable, just and inclusive energy transition. As it can be depicted in the breakdown of this future scenario (see figure below), by 2050, electricity will become by far the most important energy carrier. Under the 1.5°C Scenario, direct electricity consumption in end-use sectors (excluding the electricity needs for green hydrogen production) would more than double compared to 2018, reaching close to 50'000TWh by 2050. Transport and hydrogen production will emerge as significant new electricity markets.

In addition, around 20'770TWh would be needed to produce green hydrogen by 2050. The direct electrification share of final energy consumption, which includes direct-use of electricity but excludes indirect-uses such as e-fuels, will exceed 50% by 2050. The use of green hydrogen and green-hydrogen-based carriers, such as ammonia and methanol, as fuels, can reach 7% in 2050 from negligible levels today[25]. In total, direct and indirect electrification would reach 58% of final demand.

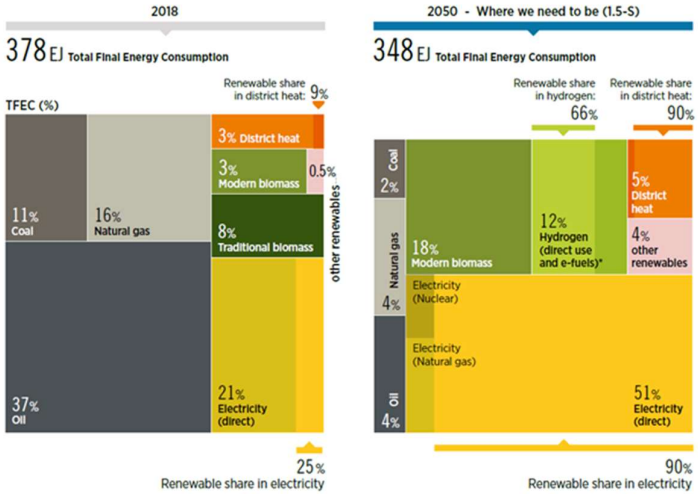

Figure 15: Breakdown of total final energy consumption (TFEC) by energy carrier in 2018 and 2050 (EJ) in the 1.5°C Scenario

Source: IRENA (June 2021)

Note: The figures above include only energy consumption, excluding non-energy uses. For electricity use, 25% in 2018 and 90% in 2050 are sourced from renewable sources; for district heating, these shares are 9% and 90%, respectively; for hydrogen (direct use and e-fuels), the renewable energy shares (i.e., green hydrogen) would reach 66% by 2050. The category "Hydrogen (direct use and e-fuels)" accounts for total hydrogen consumption (green and blue) and other e-fuels (e-ammonia and e-methanol). Electricity (direct) includes all sources of generation: renewable, nuclear and fossil fuel based. 1.5-S = 1.5°C Scenario; EJ = exajoule.

The high expectation of utilizing green electricity to decarbonize the energy sector brings into attention that the transport sector will require a dramatic change. In the share of electricity in final energy consumption would rise from 1% in 2018 to 49% by 2050. Technological progress, notably the evolution of batteries, has greatly improved the economic case for electric vehicles in recent years, and the scope of application is quickly expanding to a broader set of road vehicle segments and types of services.

If ongoing cost reduction trends consolidate, by 2050 the bulk of global road transport services could be delivered cost-effectively with electric technology. In IRENA's 1.5°C Scenario, electric vehicles account for more than 80% of all road transport activity by 2050 (88% of the technology mix in light-duty vehicles and 70% in heavy-duty vehicles). The stock of electric cars would rise from 10 million today to over 1 780 million by 2050; the stock of electric trucks would rise to 28 million by 2050.

Another notable conjunction in the electrification of end-use sector is expressed within industry activities. The direct electrification share in industry would rise from 28% in 2018 to 35% by 2050. Already many electricity-intensive industries such as aluminium smelters are linked with generation assets that offer cheap electricity from hydropower, and this is likely to increase in the coming years.

For low-temperature industrial heat needs, heat pump installations would increase to 80 million by 2050. Electricity is already the single-largest energy carrier in the buildings sector, making up 32% in 2018, and this share will rise to 73% in 2050 in the 1.5°C Scenario. This is equivalent to 21'300 terawatt hours by 2050, a doubling of electricity demand in the sector compared to the 2018 level. Driving this increase is not just the wider adoption of electric appliances, but significant electrification of heat, growth in cooling demand and electric cooking. In addition, heat pumps are a key and efficient technology and will grow eight-fold to over 290 million units installed by 2050 compared to 38 million units in place today.

Accordingly, the double axis of electrification and efficiency in the energy transition has two relevant sectors that generate a set of challenges and opportunities. Both transport and industry, will be two of the main sectors that will be decisive in order to achieve the results needed in a 1.5°C Scenario.

Flexibility in the power system

A cornerstone in the tenet of electrification of the energy sector implies that higher rates of variable renewable energy integrated in the energy systems, then a wider set of responses are needed to couple with flexibility. By 2050, 73% of the installed capacity and 63% of all electricity generation would come from variable resources (solar PV and wind), up from 15% of installed capacity and 7% of electricity generation in 2018. Such a level could be manageable with current technologies leveraged by further innovations beyond technologies extending to market design, regulations and system operation measures. For instance, thirty flexibility options were identified by IRENA as part of its innovation tool that may be combined into comprehensive solutions, taking into account the specifics of economy-wide and regional power systems[26].

On a technology level, both long- and short-term storage will be important for adding flexibility. The production of a very large volume of hydrogen from renewable power in combination with hydrogen storage can help provide long-term seasonal flexibility. Flexibility will also be provided through additional measures, including power grid expansion and operational measures, demand-side flexibility solutions, power-to-heat and other sector coupling options[27]. Smart solutions, such as smart charging of electric vehicles, can greatly facilitate the integration of VRE by leveraging storage capacity and the flexibility potential of the demand side[28].

The role of hydrogen is vital

As global economies aim to become carbon neutral, competitive hydrogen and synthetic fuels derived from hydrogen, such as ammonia, methanol and kerosene, will offer an emission mitigation solution to industry and transport sectors, which are hard to decarbonise through direct electrification. Hydrogen can help to achieve carbon neutrality in energy-intensive, hard-to-decarbonise sectors like steel, chemicals, long-haul transport, shipping and aviation. It can also play fundamental roles in balancing renewable electricity supply and demand by absorbing short term variations as well as acting as an option for long-term storage to help balance renewable variability across seasons.

The 1.5°C Scenario, green and blue hydrogen production grows from negligible levels today to over 74 exajoules (EJ) in 2050. In this context, hydrogen needs to be low carbon from the outset and ultimately green, that is, produced by electrolysis of water using renewable electricity. Green hydrogen currently costs between two and three times more than blue hydrogen, which is produced using fossil fuels in combination with carbon, capture and storage (CCS). Falling renewable power costs and improving electrolyser technologies could make green hydrogen cost competitive by 2030[29].

Sustainable bioenergy in the energy transition

Bioenergy including solid biomass, biogas and biomethane, and liquid biofuels, makes up a large share of renewable energy use today and will remain a significant source of fuel, both in industry and transport. Bioenergy in total would represent 25% of total primary energy supply by 2050 in the 1.5°C Scenario. Such a level translated to the need of just over 150 EJ of biomass primary supply, a three-fold increase compared to 2018 levels. Although the estimate is at the higher end of the sustainable biomass supply potential estimated by IRENA and other institutions for 2050 (IRENA, 2014, IRENA, 2021, 2016a, 2016b; Faaij, 2018, see references at the end of this section), such a level can in principle be supplied sustainably without causing negative land-use changes.

However, a major challenge is to scale up biomass production to those levels, while avoiding adverse environmental or social consequences. To ensure that biomass supply is environmentally, socially and economically sustainable, it is pivotal to deploy globally robust policy frameworks for regulation, certification and monitoring, and responsible sourcing practices by industry actors.

On application side, bioenergy will be needed across the energy to provide heat in industrial processes and feedstock in the petrochemical industry to produce chemicals and plastics, cooking and space and water heating in buildings and fuels for transport, especially in the aviation sector.

In the light of sustainable development goals of increasing access to clean cooking fuels, traditional uses of bioenergy (representing around one-quarter of energy demand in 2018, much of it unsustainably sourced and inefficiently used) will be replaced with a combination of

modern biomass cook stoves, biogas and electric stoves. Additionally, the use of biomass coupled with CCS in the power sector and some industrial sectors will be critical in delivering much needed negative emissions to achieve the carbon neutrality goal.

Carbon capture and sequestration and BECCS

While much can be achieved by electrification and efficiency to decarbonize the future in a 1.5°C Scenario, some emissions remain in 2050 from fossil fuel use and industrial processes. There will thus be a need for both CCS technologies and also CO_2 removal (CDR) measures and technologies that, combined with long-term storage, can remove CO_2 from the atmosphere, resulting in negative emissions.

In the 1.5°C Scenario, the role of CCS is limited, targeting process emissions from cement, iron and steel, hydrogen and chemical production, with a limited deployment for waste incinerators. Together the use of CCS and CCU in industry and CCS for fossil-fuel-based hydrogen production expand from 0.04 Gt/year of captured CO_2 today, accounting 24 commercial fossil-fuel-based CCS and CCU facilities in operation globally, to 3.4 Gt/year of CO_2 in 2050.

CDR measures and technologies include nature-based measures such as reforestation as well as BECCS, direct carbon capture and storage (DACCS) and some other approaches that are currently experimental. In the 1.5°C Scenario, the use of BECCS in power, co-generation plants and some industrial processes such as cement, chemicals and pulp mills, would require rapid scaleup leading to 4.7 Gt/year of CO_2 captured and stored per annum in 2050, compared to less than 0.002 Gt/year of CO_2 captured in 2020 from three operational commercial plants. For the latest update on this subject see IRENA's report -Reaching Zero with Renewables – Capturing Carbon (IRENA, October 2021). This Technical Paper explores the status and potential of carbon capture and storage (CCS), carbon capture and utilisation (CCU) and carbon dioxide removal (CDR) technologies and their roles alongside renewables in the deep decarbonisation of energy systems. The paper summarises the status of these technologies in terms of current deployment and costs, potential future roles, and the challenges and prospects for scaling-up their use in the context of the 1.5°C climate change goal and achieving net-zero emissions by 2050.

From technology avenues to the investment arena

In the WETO (2021) is crystal clear that a palate of technologies, measures and solutions are needed to ensure a sustainable energy transition. This brings into question the gap between research, development and deployment of this technological matrix, which can be vast depending on which technology or solution is outlined.

A climate-safe future calls for the scale-up of investment from the currently planned USD 98 trillion between 2021 and 2050 under the Planned Energy Scenario (PES) to USD 131 trillion under the 1.5°C Scenario (see figure below). This represents an incremental increase of 34% in investments from the planned investments until 2050. This investment in the 1.5°C Scenario will yield a cumulative payback of at least USD 61 trillion by 2050. Hence, the overall balance from the energy transition is positive, with benefits greatly exceeding costs.

The 1.5°C Scenario demands an additional investment of USD 1.1 trillion per year over the PES, plus the redirection of investments from fossil fuels towards energy transition technologies i.e., renewables, energy efficiency and electrification of heat and transport. This makes up to more than 80% of the total energy sector investments, namely, USD 116 trillion in cumulative terms to 2050 or in annual terms of USD 3.8 trillion per year.

On average, over the next three decades the investment needed for the energy transition represents only about 5% of global gross domestic product (GDP) in 2019. This is within the current capacity of global financial markets, which reached a volume of some USD 200 trillion in 2019 (World Bank, 2019; SIFMA, 2020, see references at the end of this section).

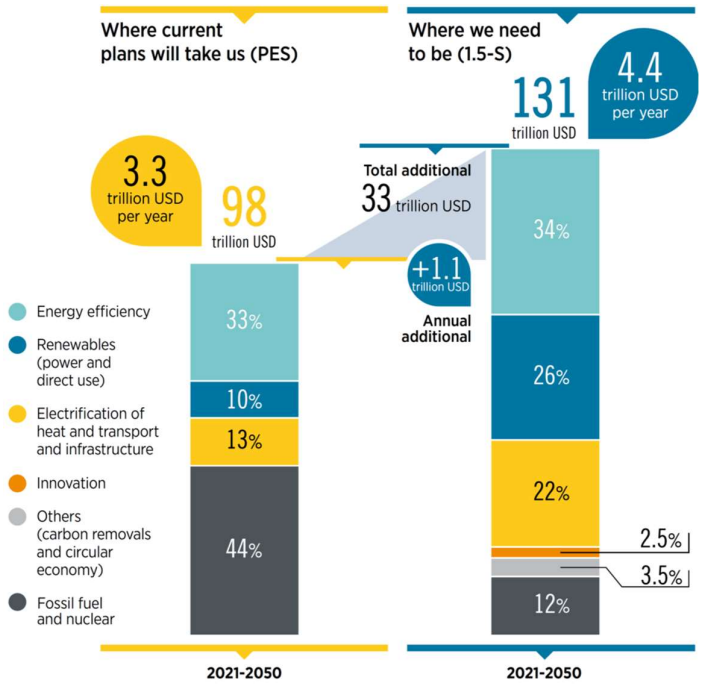

Figure 16: Total investment by technology: PES and 1.5°C Scenario (2021-2050)

Source: IRENA (June 2021)

High upfront investments are critical mainly to enable the accelerated deployment of key renewable energy technologies in the power sector; a massive scaling up of electrification of transport modes and heating applications, along with an expansion of accommodative infrastructure; and large-scale green hydrogen projects.

In order to understand the investment implications of the technological avenues highlighted in the WETO (2021), Table below depicts a breakdown of the investment that is needed, by comparing historical annual investments per year in relation to the 1.5°C Scenario.

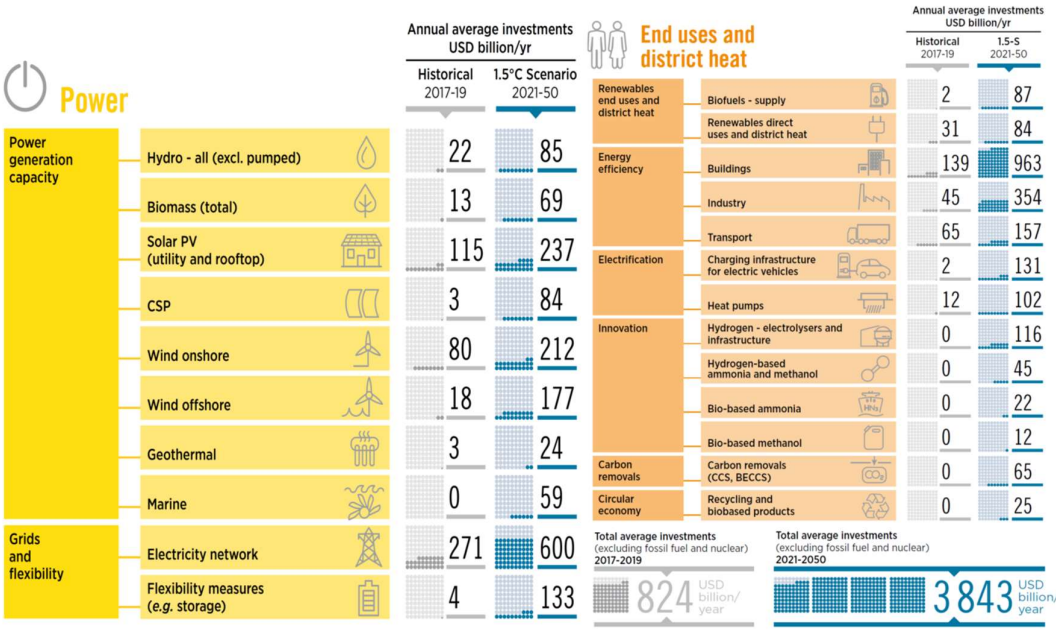

Table 1: Annual average investments in power and end uses, historical (2017-2019) and needed to meet 1.5°C Scenario (USD billion/year)

Source: IRENA, June 2021

Note: **Power generation capacity**: Deployment of renewable technologies for power generation. **Grids and flexibility**: Transmission and distribution networks, smart meters, pumped hydropower, decentralised and utility-scale stationary battery storage (coupled mainly with decentralised PV systems) and hydrogen for seasonal storage. **Renewables direct uses and district heat**: Renewables in direct end-use and district heat applications (e.g., solar thermal, modern bioenergy). **Energy efficiency in industry**: Improving process efficiency, demand-side management solutions, highly efficient energy and motor systems, and improved waste processes. **Energy efficiency in transport**: All passenger and freight transport modes, notably road, rail, aviation and shipping. Key efficiency measures include light-weight materials, low friction designs, aerodynamic improvements, among others. Vehicle stock investments are excluded. **Energy efficiency in buildings**: Improving building thermal envelopes (insulation, windows, doors, etc.), deploying efficient lighting and appliances, equipping smart homes with advanced control equipment, replacing less efficient buildings with energy efficient buildings. **Hydrogen electrolyser and infrastructure**: Electrolyser capacity (alkaline and polymer electrolyte membrane) for the production of green hydrogen and infrastructure for the transport of hydrogen. **Bio- and hydrogen-based ammonia and methanol**: Production of ammonia and methanol from biomass and hydrogen feedstocks. **Carbon removals**: CCS deployment, mainly for process emissions in industry and blue hydrogen production. BECCS deployment in cement and power and cogeneration plants. **Circular economy**: Material and chemicals recycling and bio-based alternative products (e.g., bioplastics). **BECCS** = bioenergy with CCS; **CCS** = carbon capture and storage; **CSP** = concentrated solar power.

In the power sector, accelerated investment of USD 1.7 billion per year would account for 44% of the total required energy transition investment over the period to 2050. Investments would be directed towards additional renewable power generation capacity, grid extension and grid flexibility measures ranging from better renewable power generation forecasting to integrated demand-side flexibility and stationary battery storage, or so-called Power to X.

Transport investments would rise to USD 375 billion per year counting for 10% of the total transition-related investment. This excludes the incremental costs of electric vehicles.

When it comes to hydrogen, Investments in electrolysers, hydrogen supply infrastructure and renewables-based hydrogen feedstocks for chemical production would exceed USD 161 billion per year on average through 2050.

Bioenergy investments would rise to USD 226 billion per year (6% of total transition-related investment), most of it to increase the biofuels supply.

The average annual investment needed in the buildings sector will count for USD 1.09 trillion per year. This investment is dominated by energy efficiency investment counting for USD 0.96 trillion per year and the remainder investment going for heat pumps and uses of other renewables, largely solar thermal.

Current government strategies already envisage significant investment in the energy sector counting for USD 98 trillion by 2050. Collectively referred in the WETO (2021) as the Planned Energy Scenario (PES), this scenario imply a near doubling of annual energy investment, which in 2019 amounted to USD 2.1 trillion. Substantial funds will flow towards modernization of ailing infrastructure and meeting growing energy demand. However, the breakdown of financing for technology under the 1.5°C Scenario differs greatly from current plans in PES. Namely, USD 24 trillion of planned investments will have to be redirected from fossil fuels to energy transition technologies between now and 2050.

Funding structures in the 1.5°C Scenario are markedly different in terms of capital sources, public and private, and types of capital, equity and debt. In 2019, USD 1.6 trillion in energy assets were financed by private sources, accounting for 80% of total energy sector investment. That share would grow dramatically under the 1.5°C Scenario. The share of debt capital needs to increase from 44% in 2019 to 57% in 2050, almost 20% more than under the PES.

Conclusion

A net zero carbon future by 2050 might be perceived as a daunting challenge. Much of today's energy infrastructure and capital stock would need to be replaced in the next three decades to translate this vision into a reality. The world needs to capitalize by taking immediate, collaborative and concrete actions to meet the challenge of climate change.

IRENA's analysis condensed in the WETO (2021) indicates that such a transformational quest is feasible. Achieving it will require a massive effort that highlight several fronts that require attention when it comes to link the aims and goals of technological solutions and measures within current investment capacities and opportunities. These core features can be outlined as it follows:

1. The rate of decline in energy intensity must move from the 1.2% recorded in recent years to 3%. Here, renewable power, electrification and circular economy principles have key roles to play, as do conventional energy efficiency technologies.
2. Annual growth in renewable energy's share in the globe's primary energy production needs to accelerate eight-fold from its share in recent years.
3. Renewable power generation capacity must grow from over 2 800 GW today to 27 500 GW by 2050, or 840 GW per year and a fourfold increase in the annual capacity additions recorded in recent years.
4. Electric vehicle sales must grow from 4% of all vehicle sales today to 100%, with the stock of electric vehicles growing from 7 million in 2020 to 1.8 billion in 2050.
5. Hydrogen demand must increase from 120 Mt to 614 Mt in 2050, a fivefold increase. The share of clean hydrogen in overall demand needs to grow from 2% to 100%. Two-

thirds of demand would be met by green hydrogen; one-third by blue. Meeting that goal will require the addition of 160 GW of electrolysers each year between now and 2050, from the 2020 base of 0.3 GW of installed capacity.

6. The total primary supply of biomass needed to achieve net zero emissions by 2050 would be just over 150 EJ, a near tripling of primary biomass use in 2018. Based on a detailed assessment of the potential supply of sustainable biomass, this appears feasible.
7. Carbon capture and storage must grow from 0.04 Gt captured in 2020 to 7-8 Gt in 2050, with BECCS accounting for half for the total amount captured and stored.
8. Investment in the energy transition will need to increase up to 34% from planned levels. This implies USD 131 trillion over the period to 2050 under the 1.5°C Scenario. This investment in the 1.5°C Scenario will yield a cumulative payback of at least USD 61 trillion by 2050.
9. A holistic global policy framework is necessary to guide climate action under the 1.5°C Scenario. Climate policies, including fiscal policy aligned with climate objectives, represent an important component of such a framework. A diverse portfolio of measures and instruments focused on enabling and supporting the transition must be integrated into a wider and transparent policy strategy that accounts for the fact that policies introduce strong links and feedback between energy, economic and social systems.

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1.1.3. Key Variables for Carbon Neutrality Scenarios

Urban planning of the future should facilitate cities and municipalities developing on the Race to Zero pathway. The race to zero means satisfying two contradicting objectives: on the one hand, diminishing global CO_2-emissions as quickly as possible, while on the other hand keeping GDP steadily increasing. Even though this is altogether a complex process, its essential aspects can be summarized in a simple way by using just few key data series: population, CO_2-emissions, GDP, energy, and renewable energy. Four of these series are being used in the Kaya identity named after his developer, the Japanese energy economist Yoichi Kaya[44]. The Kaya identity states that

Emissions = population x (emissions/energy) x (energy/GDP) x (GDP/capita)

By dividing the equation by population, the second equation below can be found.

$$\frac{emissions}{capita} = \frac{emissions}{GDP} \times \frac{GDP}{capita}$$ Basic relationship: emissions, population, GDP

$$\frac{emissions}{capita} = \frac{emissions}{energy} \times \frac{energy}{GDP} \times \frac{GDP}{capita}$$ disaggregating emissions/GDP

$$\frac{emissions}{capita} = \frac{emissions}{energy} \times \frac{energy}{capita}$$ showing per capita energy use

Disaggregating energy into its renewable and non-renewable parts

$$\frac{emissions}{capita} = \frac{emissions}{renewable+other\ energy} \times \frac{renewable+othe\ \ energy}{capita}$$

Figure 17: Equations derived from the Kaya identity

Source: APSEC

The key indicator for measuring progress between contradictory objectives such as emissions and GDP is the emissions intensity of GDP (emissions/GDP). For this reason, the first formula above puts this indicator to evidence. The easiest way to keep population within all these formulae is to use per capita data throughout the formulae, that is per capita emissions on the left, and per capita GDP or per capita energy on the right. The table is self-explanatory about the mathematical transformations.

Emissions intensity of the world as well as in the APEC region have diminished over the past decades. Since the financial crisis in 2009, the diminution has been faster at global average as well as in the APEC region. During the period 1990 – 2009, global emissions intensity has diminished linearly by 4.6 tCO_2/million USD PPP 2017 per year, and by 7.2 tCO_2/million USD PPP 2017 per year in the decade 2010 – 2020. APEC emissions intensity diminished linearly by 5.1 tCO_2/million USD PPP 2017 per year in the period 1990 – 2009 and

by 10.5 tCO_2/million USD PPP 2017 per year in the period 2010 – 2020. In APEC, the linear diminution in the second period was more than double of the linear diminution of the first period. If the trend since 2010 continues, APEC will be carbon neutral in 2050, and the world in 2057.

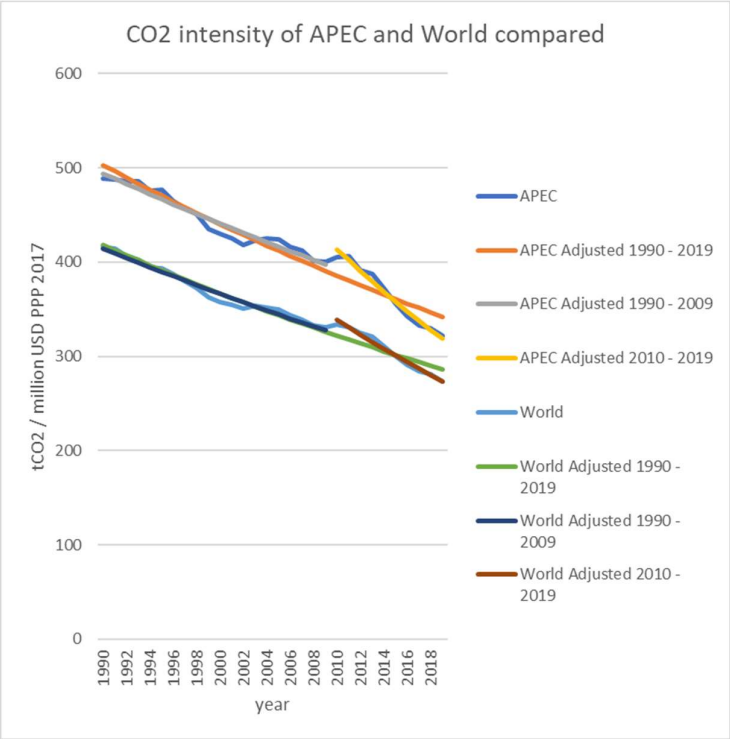


Figure 18: Emissions intensity of APEC and world compared

Source: APSEC, based on StatsAPEC data

The second formula in the figure about the Kaya identity above shows the relative role of increased decarbonization of energy (emissions/energy) and increased energy efficiency (energy/GDP) during the race to zero.

The third formula shows per capita energy use.

The fourth formula shows how evidencing the role of renewable energy is possible at the end by separating energy into two parts, renewable and other energy. Renewable energy is the dominant contributor to de-carbonize energy, i.e., diminish the emissions/energy ratio.

These few data series allow characterizing the possible pathways by their mix of carbon-free energy and energy efficiency as will be shown further down. Before going into these details, it is necessary to give some further explanations about *a carbon neutral society*. It will be argued here that a carbon neutral society is in reality a "1t CO_2-society", meaning a society which emits at least 1 ton CO_2 per capita per year which is the floor level of gross per capita CO_2 emissions.

Addressing climate change implies making global emissions inventories of all possible GHG sources. If this inventory comprises all anthropogenic CO_2 emissions, this includes at least three different sources: 1) emissions caused by fossil energy technologies (comprising all combustion engines and combustion devices), 2) emissions caused by agricultural livestock, and 3) emissions caused by human metabolism. This report defines a carbon neutral society

as a society having the same biological components as today, but whose energy technologies are all CO_2 neutral. The biological components are essentially human beings and agricultural livestock. The "1t- CO_2-society" therefore allows CO_2 emissions originating from human physiological activity and those originating from agricultural livestock. CO_2 emission from human physiological activity can be estimated by direct measurement of energetic activity and multiplied by the relevant CO_2 coefficients. The figure below is taken from a life cycle assessment of the average Spanish diet published in 2010. It states the average annual per capita emission from food ingestion in Spain as 276kg CO_2, 222kg water, and 90g CH4 (methane), whereby 242 kg of physiological oxygen is being consumed per capita every year. These figures are not necessarily representative of the global average. Food energy supply worldwide varies from the simple to the double depending on the culture and development level. Furthermore, average global food energy supply has increased by 33% between 1961 and 2019, reaching 2920kcal/day/person[45] of which some 17% are wasted[46]. Physiological per capita CO_2 emissions would show the same pattern.

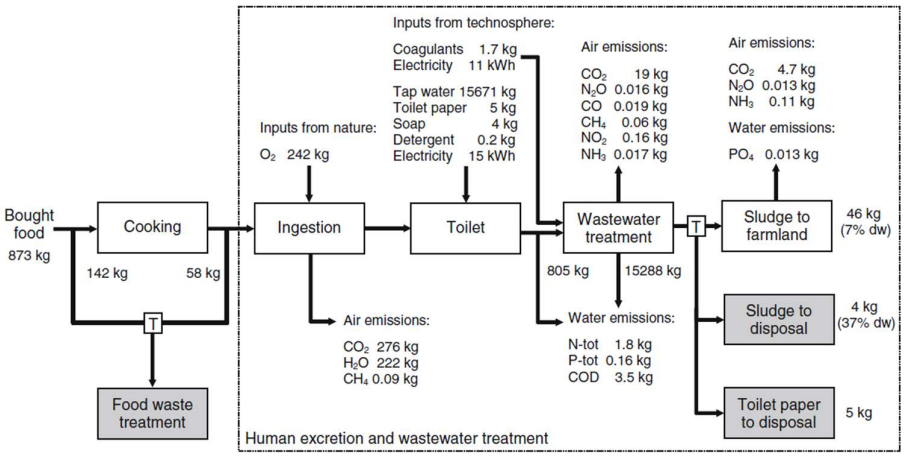


Figure 19: Environmental annual per capita balance of food

Source: Ivan Muñoz and others (2010) [47]

The Global Warming Potential (GWP) of methane is much higher than the one of CO_2 and should, therefore, not be automatically neglected. At the time of its emission, the GWP of methane is 120 times as high as the GWP of CO_2. As methane is disappearing from the atmosphere due to interactions with other gases, it has an average lifetime in the atmosphere of about 12 years[48], which is much shorter than the one of CO_2 which stays in the atmosphere during hundreds of years. For this reason, the Accumulated Global Warming Potential (AGWP) of CO_2 steadily increases with time whereas the AGWP of methane flattens after about 40 to 50 years. After 100 years, the AGWP of methane is around 23 times as high as the one of CO_2. This factor (23) is most often cited when Global Warming Potential (GWP) of methane is compared with GWP of CO_2.

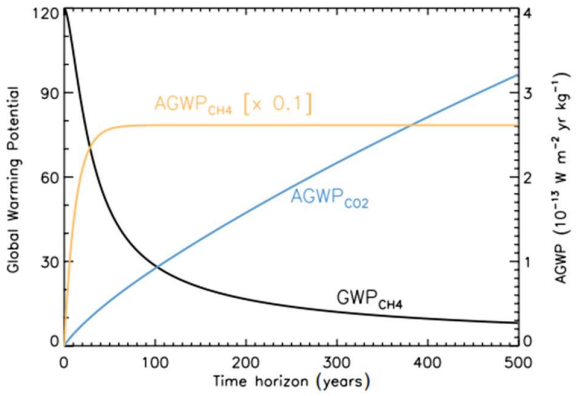


Figure 20: Global Warming Potential and Accumulated Global Warming Potential

Source: IPCC WG1 AR5 Chapter 08 Radioactive forcing [49]

An estimate of the CO_2 emissions of livestock can be taken from the Global Livestock Environmental Assessment Model (GLEAM) of the FAO, available in several languages. GLEAM 2.0 (2017) includes an assessment of greenhouse gas emissions. Global livestock emissions amount to 7608 Mt CO_2-eq in total (see fig below). The figure also shows the mitigation potential, whereby producers in each system, region and agroecological zone were to apply the practices of the 10th percentile of producers with the lowest emissions intensities, while maintaining constant output and without making changes to farming systems. In that scenario, the global livestock emissions would be lowered from 7608 Mt CO_2-eq (or about 950kg CO_2 per capita) to 5075 Mt CO_2-eq (or about 630kg CO_2eq per capita).

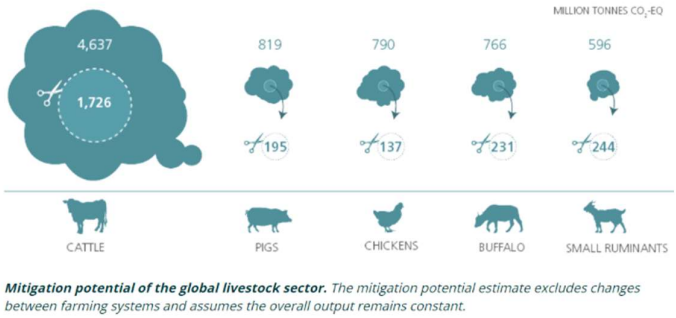


Figure 21: CO_2-eq and mitigation potential of global livestock sector

Source: FAO GLEAM 2.0[50]

In sum, the GHG per capita emissions of agricultural livestock and human metabolism can be said to be at least 1t CO_2 per year, of which less than one third is from human metabolism and more than two thirds from agricultural livestock. With present global population of 8 billion, present global CO_2 emissions amounts to 8Gt CO_2 per year which compares to the pre-industrial (1750) level of around 9.5Gt CO_2 per year[51]. As global population is likely to peak around the 10 billion level, a comparable emission level would presumably be sufficiently low to be absorbable by land and oceans. At present, global GHG emissions are around 50Gt per year, of which three quarters (37Gt) are CO_2, 17% methane, 6.2% nitrous oxide and 2.1% fluor gases[52]. Absorption by land and oceans depends on the cumulative emissions stored in the atmosphere. The scale on the figure below indicates the cumulative CO_2 emissions since 1850.

The grey area shows the proportion of CO_2 stored in the atmosphere. The scenarios are differentiated by their respective radiative forcing measured in W/m2. As an example, SSP5-8.5 means radiative forcing of 8.5W/m2. In this example, the anthropogenic radiative forcing of 8.5W/m2 is added to the 324W/m2 of non-man-made or natural radiation coming from the atmosphere to the earth surface[53] and causing mean atmospheric temperature to rise above the pre-industrial average level of 15°C. Due to the century-long life of CO_2 in the atmosphere, limiting emissions to 1t CO_2 per capita by 2050 might be sufficient to stabilize the average global temperature at 16.5°C, but not to bring it back to the earlier level.

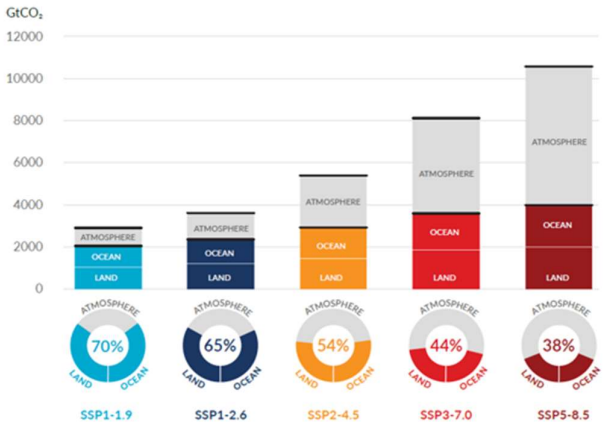


Figure 22: Proportion of CO_2 emissions taken up by land and ocean carbon sinks

Source: IPCC 6th Assessment Report (AR6 WG1), August 2021[54]

The equations presented further above are now used to state decarbonization objectives. At present, annual global per capita CO_2 emissions are just under 5t. Achieving carbon neutrality means diminishing CO_2 emissions by a factor 5. At the same time, GDP per capita PPP is expected to grow as BAU, i.e., by 1.75% per year, doubling by approximately 2060. The scenario below provides for a high contribution of decarbonization (emissions/energy) decreasing fivefold, combined with a relatively low contribution (2fold decrease) of energy intensity (energy/GDP). Energy per capita would result in roughly the same level as today. With a 5fold decarbonization of energy (emissions/energy), this scenario is one of rapid development of renewable energy.

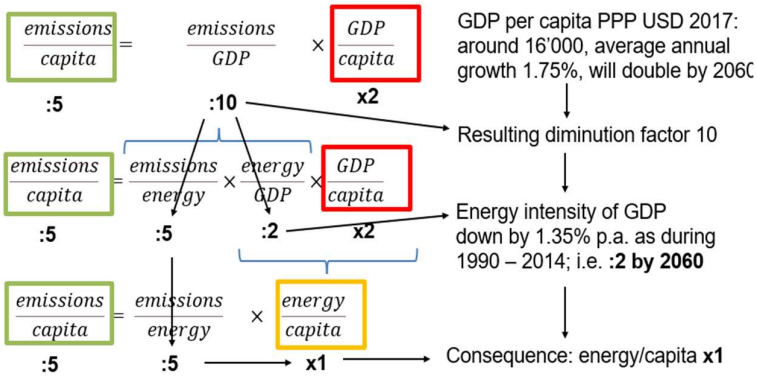


Figure 23: Example 1 of global scenario: rapid decarbonization and slow energy intensity

Source: APSEC

In the second example, if energy intensity (energy/GDP) improvement speed is doubled compared to the base period and reaches 2.7% p.a. as postulated by SDG 7.3, this will result in a stronger contribution of energy intensity (diminish 4fold) by 2060. The two objectives of diminishing emissions per capita and increasing GDP per capita can now be attained even if decarbonization of energy is quite slower (2.5fold decrease). In this scenario, energy per capita will diminish by half by mid-century.

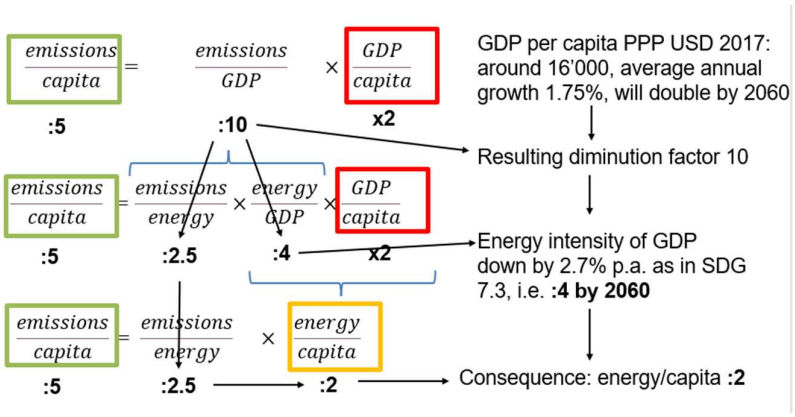


Figure 24: Example 2 of global scenario: medium decarbonization and double energy intensity

Source: APSEC

In a third scenario, decarbonization of energy is even slower (around 1% p.a.), corresponding to the speed in the base period 1970 – 2000 and decreasing only 2fold by mid-century, then energy intensity improvement must be very high (diminish 5fold) to still attain both goals, the emission per capita and the GDP per capita. Note that in this scenario, energy per capita will diminish 2.5fold by 2060, due to the very strong role of energy efficiency.

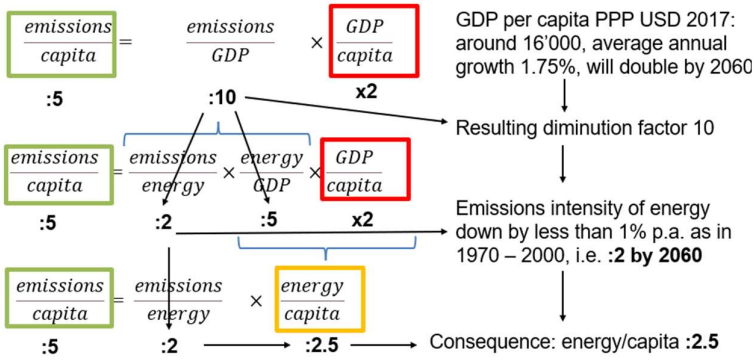


Figure 25: Example 3 of global scenario: slow decarbonization and very high energy intensity

Source: APSEC

These three scenarios show that the faster the decarbonization (i.e., the greater the role of renewables), the less important the required contribution by energy efficiency to attain carbon neutrality. Conversely, the slower renewables grow, the higher is the required contribution of energy efficiency to attain carbon neutrality. In the real world, energy efficiency is likely to diminish faster than above scenario 1 (dividing by 2 by 2060) but slower than above scenario 2 (dividing by 4 by 2060), requiring decarbonization of energy to take place at a factor between division by 5 and division by 2.5 by 2060.

1.1.4. 2000-Watt-Society as Complement to Carbon Neutrality

The question arises in this context of how much energy per capita would be necessary for, or at least compatible with, maintaining carbon neutrality (i.e., the 1t CO_2-society) over the long term. The above-described scenario-tool concentrates on the interplay between emissions per capita and GDP per capita. Energy per capita is somewhere in between. For 2019, the IEA[55] (Key World Energy Statistics 2021) indicates 79.1 GJ/capita/year for total global per capita energy supply (2019 data). The total final energy consumption (TFC) is 417.973EJ or 54.5GJ/capita/year. These two figures convert to approximately 2500W and 1730W for per capita primary and final energy, respectively.

To describe the necessary per capita energy consumption in a long term in a global perspective, recent literature[56] created the concept of decent living standard (DLS) and calculated the minimum energy requirement for DLS. The DLS is defined in a bottom-up approach identifying eight different dimensions (nutrition, shelter, hygiene, clothing, healthcare, education, communication, mobility) and for each dimension a certain number of services (e.g., for the first dimension: food, cooking appliances, cold storage), for which activity levels are determined and the associated energy consumption calculated. The calculations consider climatic and cultural differences but are independent of GDP. The result is given in the figure below, differentiating between global minimum, global mean, and global maximum of 13.0, 15.3, and 18.4 GJ/capita/year, respectively. The three values of 13.0, 15.3 and 18.4 GJ/capita/year can be converted to 412, 485 or 585J/s/capita, or 412, 485 or 585W per capita, respectively. The minimum energy level for DLS can be averaged to 500W per capita. This indicates the long-term bottom level of energy efficiency. The colours in the figure below show the breakdown into different services. Food (dark green) and vehicles (orange) are the biggest components. The right-hand figure shows where today's world is compared to the DLS which is indicated by the narrow green line.

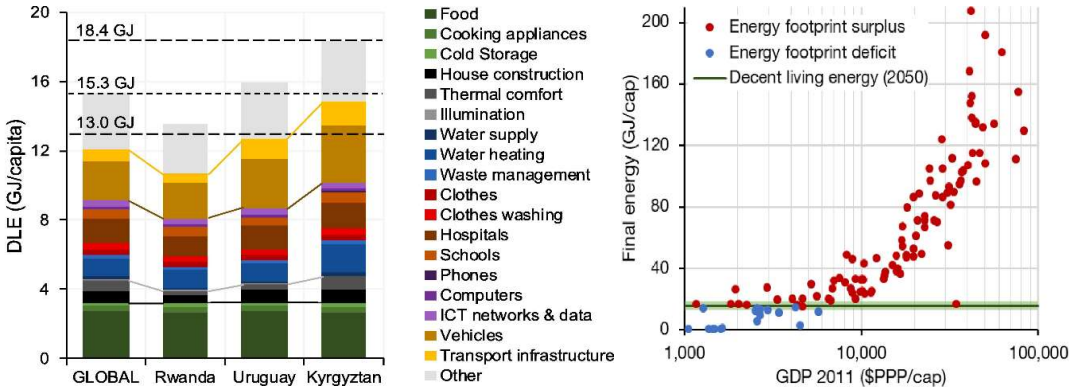


Figure 26: Final energy for a Decent Living Standard (DLS)

Source: Millward-Hopkins and others[57]

Thus, the per capita energy requirement for DLS is about 5 times lower than today's global per capita total energy supply (TES), or 3.5 times lower than today's global per capita total final energy consumption (TFC). Note that the DLS should normally be compared to TFC rather than to TES. This comparison shows that even the third scenario above with five-fold energy intensity improvement and two-and-a-half-fold energy per capita diminution by 2060 is still far

away from diminishing energy per capita by a factor 3.5 by 2060, which would be the DLS bottom level.

The per capita energy requirement for DLS can also be cross-checked with today's global per capita food energy supply (2939.54kcal/day/person)[58] equalling 142W/capita which are available at the end of the food supply chain, of which 17%[59] is wasted at the end of the food supply chain, leaving about 120W/capita (or 3.8GJ/year/capita or 2500kcal/day/capita) as effective food energy consumption today. Food energy consumption is shown dark green in the above DLS figure. In other words, DLS as regards food energy consumption is practically the same as today's food energy consumption net of the waste at the end of the food supply chain.

It is now interesting to analyse to what extent renewable energy can contribute to satisfy the energy requirements of DLS. For this analysis, it is assumed that all non-food energy of DLS, that is all the energy except the dark green bars in the left figure above should be supplied by renewable energy. The non-food energy requirement of DLS is calculated by deducting 120W per capita from 412, 485 or 585W per capita, giving 292, 365 or 465W per capita, respectively, rounded to 380W per capita.

An SDG indicator that can be used to track this is 7.b.1, *Installed renewable energy-generating capacity for developing economies* (in watts per capita). According to the metadata for this indicator[60], it is to be understood as renewable *electricity*. Translating the installed capacity to the effective renewables production requires knowledge of the capacity factor of each technology. Capacity factors can be calculated for each technology based on available statistics. The figure below shows that in 2020, the capacity factor was highest for geothermal electricity (75%, left hand scale), while for offshore wind energy it was 33%, for total renewable electricity 30%, for onshore wind 24%, for concentrated solar power 23%, and for photovoltaic 13%.

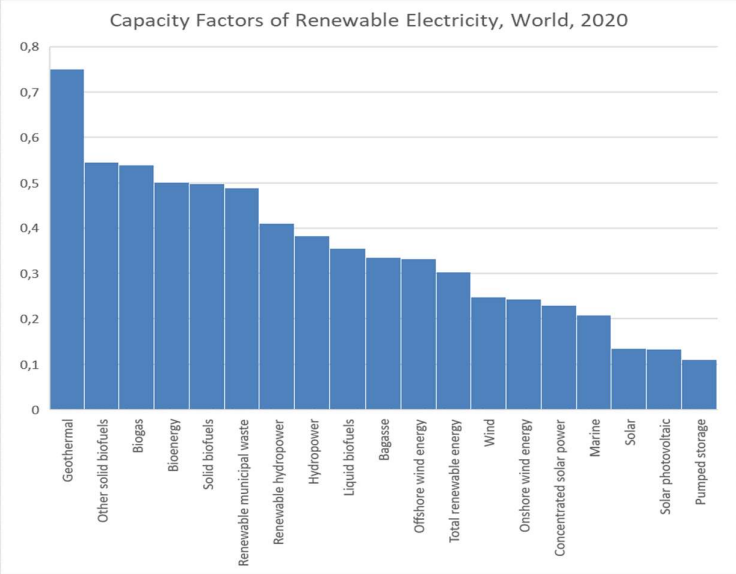


Figure 27: Capacity factors for renewable electricity

Source: APSEC based on IRENA data[61]

A long-term development in which wind and solar would play a stronger role would probably bring down the total average capacity factor of renewable energy to around 20%. To generate 380W per capita in the long term, the installed renewable electricity-generating capacity would

therefore have to be around five times higher, that is 1900W per capita. This allows specifying the earlier concept of the 2000W-(or 2kW)-Society[62] as a society in which all non-food energy requirements of a Decent Living Standard (DLS) are satisfied by renewable electricity. With a capacity factor of 20%, installed renewable electricity capacity will be 1900W per capita, to which the net food requirement of 120W per capita is being added. The 2000-Watt Smart Cities Association[63] started promoting the concept of 2000W-Society at urban level.

The situation of installed renewable electricity capacity for the developing world is described in the SDG7 tracking report for 2022. It gives a differentiated picture, depending on regions. While Eastern and South-Eastern Asia and Latin America and the Caribbean have relatively higher installed capacities, the rest of the developing world lags well behind (see figure below)[64], where CAGR stands for calculated annual growth rate.

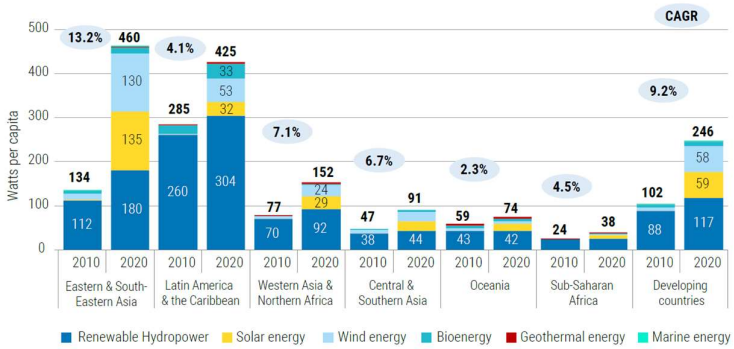


Figure 28: Growth in renewable electricity capacity per capita by technology across regions

Source: Tracking SDG7 Report[65]

At global average, the installed renewable electricity capacity was at 362W/person in 2020, showing 7% annual growth rates and a peak growth rate as high as 9.5% in 2020, possibly as a reaction to the pandemic. If growth rates of the period 2008 – 2020 continue up to 2030, the world will more than double the capacity of installed renewable electricity by 2030 and attain 718W/capita. If the same growth rate continues thereafter, the 1900W/capita threshold will be attained in 2044. By 2050, the world would attain 2900W/capita of installed renewable capacity.

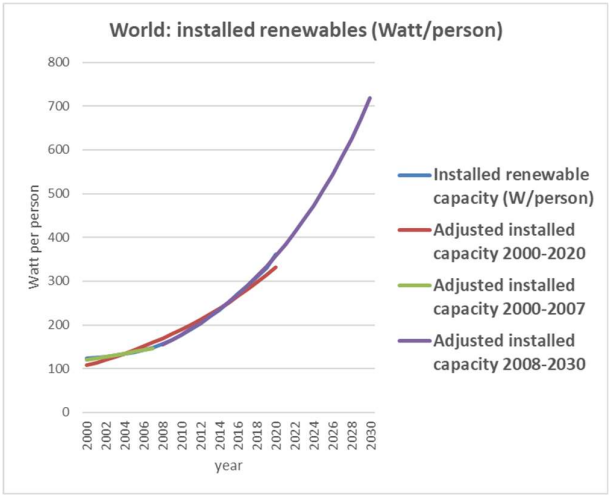


Figure 29: Installed renewable electricity capacity, world

Source: APSEC, based upon IRENA data

For APEC economies, the installed renewable energy capacity is shown in the figure below. The average per capita installed capacity in 2020 was at 561W/person. At present, only Canada has renewable installed capacity above the 1900W/person threshold.

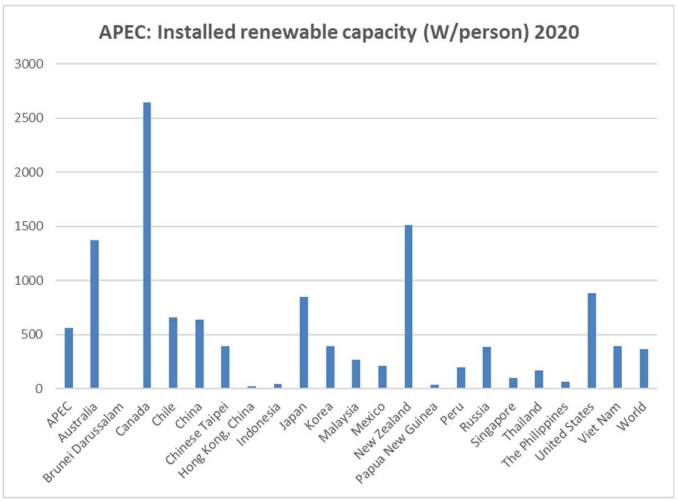


Figure 30: Installed per capita renewable electricity capacity in APEC, 2020

Source: APSEC, based upon IRENA data

Growth rates between 2005 and 2020 averaged 8.7% with a peak in the COVID19-year 2020 of 13.8%. If growth rates of the period 2005 – 2020 continue until 2030, APEC will more than double the installed renewable energy capacity and attain 1293W/capita. The 1900W/capita threshold will be attained in 2035, and by 2050 the installed capacity will attain 7300W/capita.

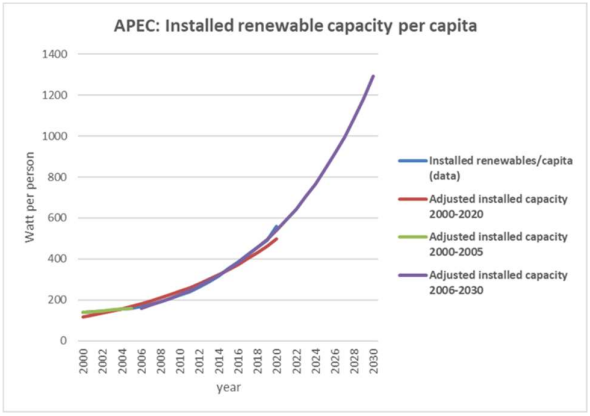


Figure 31: Installed per capita renewable electricity capacity in APEC, 2020

Source: APSEC, based upon IRENA data

The preceding sections have outlined some of the material components of carbon neutrality. The following sections will now have a closer look at the financing gap that needs to be closed to attain carbon neutrality.

1.2. Financing Gap

1.2.1. Financing Gap of the 2015 Addis Ababa Action Agenda (AAAA)

The UN 2030 Agenda for Sustainable Development was adopted in 2015 by the UN General Assembly and includes two parts: the Sustainable Development Goals and the 2015 Addis Ababa Action Agenda (AAAA), its financing arm. The substantive and formal link between the SDGs and their financing arm was a novelty, designed to ensure that SDGs could get funding for implementation.

The 2015 Addis Ababa conference was the Third International Conference on Financing for Development (FfD3). Before that, FfD1 was held in Monterrey, Mexico, in 2002, adopting the so-called Monterrey Consensus which reaffirmed the goal – originally set in 1970 – that Official Development Aid (ODA) should reach 0.7% of Gross National Income (GNI), an aggregate that is very similar to the GDP (see figure below). Besides that, Monterrey structured international financial cooperation by stressing actions within all its essential six elements:

- Improving the domestic taxation systems of the developing world
- Mobilising foreign direct investment (FDI) from the private sector
- Using trade as source for financing development
- Enhancing technical cooperation
- Addressing external debt by debt reduction and debt rescheduling
- Addressing systemic questions and follow up

These points have been reiterated in the Doha Declaration adopted at the Second International Conference on Financing for Development (FfD2) held in Doha in 2008. The Third International Conference on Financing for Development (FfD3) held in Addis Ababa in 2015 reiterated the main points of earlier conferences and established a link to the SDGs which became the main substantive targets to be financed through international cooperation, and added a seventh action area:

- Science, technology, innovation, and capacity building

Substantively, the AAAA affirms many SDGs, often by paraphrasing and repeating them. Only few paragraphs of the AAAA state concrete figures. To bridge the global infrastructure gap, including the $1 trillion to $1.5 trillion annual gap in developing economies, the AAAA calls in paragraph 14 to set up a new forum addressing sustainable and resilient infrastructure, including transport, energy, water and sanitation for all, is a pre-requisite for achieving many SDGs.

Concerning specifically the energy infrastructure, clean energy technologies including carbon capture and storage technologies, the AAAA calls in paragraph 49 for mobilising FDI from the private sector. USD 100 billion of annual investment shall be mobilised by 2020 through market-based initiatives, partnerships and leveraging development banks.

Concerning climate finance, the AAAA calls in paragraph 60 to jointly mobilize USD 100 billion of annual investment by 2020 from a wide variety of sources. SDG13.a states the same figure. COP26 in Glasgow (2021) discussed ways to attain the $100 billion target.

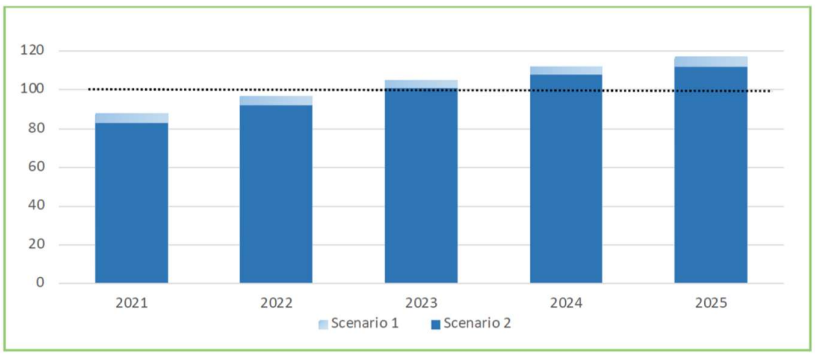


Figure 32: Scenarios to attain the $100 billion target

Source: COP26 Secretariat[66]

In paragraph 51, the AAAA re-states the objective to achieve the target of 0.7 per cent of gross national income for official development assistance (ODA/GNI) and 0.15 to 0.20 per cent of ODA/GNI to least developed economies. The same targets are stated in SDG 17.2.

To establish clarity on the meaning of the above ODA/GNI percentage and to be able to relate it to the energy investment per GDP percentage calculated by the IEA, it might be necessary to look at the difference between GNI and the GDP.

Official development aid (ODA) is customarily expressed in percentage of GNI. The use of the GNI instead of the GDP can be seen a relic of former times which is being kept by the development aid community out of fear of developing economies to lose something when changing from GNI to GDP. Prior to the 1993 introduction of the UN System of National Accounts (SNA), the GNP (=GNI) was the dominant indicator. With the 1993 reform, the GDP became the dominant indicator, except for development economics community which choose to keep the GNI. Thus, the OECD and World Bank are still using per capita GNI to differentiate between different development levels. The GNI is very closely related to the GDP as shown below.

Starting from the GDP, which designates the gross value-added produced within a defined territory, one can get the GNI by adding the incomes of primary factors (labour, capital) received by that territory from factors located outside the territory, and deduct the income paid to primary factors outside the territory. Examples of cross-border incomes of the two primary factors are: cross border commuting or posted worker's earnings, or cross-border interests, dividends, rentals, royalties (e.g., in mining industry), etc.

Gross domestic product GDP at market prices
(+) Primary incomes receivable from the rest of the world
(-) Primary incomes payable to the rest of the world
Gross national income GNI at market prices

Table 2: Difference between GDP and GNI

Source: Lequillier & Blades[67]

In short, the term "domestic" relates the cross-border incomes of the two primary factors (and only these) to the territory where they were produced, whereas the term "national" relates these cross-border incomes to the nationality of the primary factors who produced them.

For APEC economies, the difference between GNI and GDP is shown in the figure below for the year 2020. Only small open economies such as Singapore show a noticeable difference between the two in the sense of paying more interests, dividends, rentals and royalties to foreign investors or more wages to commuters from neighbouring Malaysia than vice versa, or both.

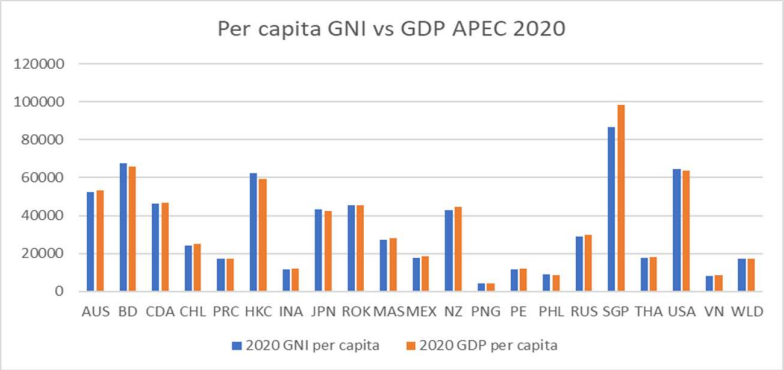


Figure 33: Per Capita GNI vs per capita GDP, APEC, 2020

Source: APSEC (data from World Bank)

In spatial analysis related to urban planning, it is more appropriate to use the GDP as it characterizes the value added within the territorial boundaries of a city. GDP can be put in relation to scope 1 GHG emissions, which are those taking place within the territory of the city.

What's more, an income-based indicator such as GNI is slightly worse for measuring economic sustainability than a product-based indicator such as the GDP, even though the latter is not perfect either. A product-based indicator such as the GDP might theoretically account for different forms of capital that are produced during a given year (e.g., infrastructures, buffer stocks, feedstocks, livestock, human skills, natural resources, resource-rich soils, biological resources, clean water, atmosphere, etc.) even if they do not generate any income during the same year. In practice, the GDP only counts additions of (a very limited choice of) stocks but fails to deduct any consumption or loss of such stocks as it is a "Gross" indicator rather than a "Net" indicator. Ideas and recommendations on how to improve the measurement of economic sustainability can be found in the final report published by the Commission on the Measurement of Economic Performance and Social Progress (Stiglitz-Sen-Fitoussi Commission) in 2009[68] which has markedly influenced the UN 2030 Agenda and the SDGs, and the follow-up work done at the OECD by the High-Level Group on the Measurement of Economic Performance and Social Progress (HLEG) which published its final report *For Good Measure – Advancing Research on Well-being Metrics Beyond GDP* in 2018[69] and a companion volume *Beyond GDP: Measuring what counts for Economic and Social Performance*[70].

An important economic sustainability concern is increasing inequality. The World Inequality Database[71] contributes to improving the knowledge about inequalities.

Having considered the above clarifications on GNI vs GDP, it becomes clear that the AAAA is addressing only a small fraction of finance needed to attain the SDGs. Both, IEA and IRENA calculated similar investment amounts of USD 5 trillion and USD 4.4 trillion, respectively, or around 4.5% global GDP during the present decade which should be invested in the energy sector each year to remain on the carbon neutrality pathway. Compared to this, the 0.7% ODA/GNI reiterated by the AAAA to be affected to all SDGs together cannot be more than a fraction of the required sum. The $1 to $1.5 trillion to be spent for infrastructures could be

equivalent to around one tenth of the necessary amount, whereas the $100 billion for clean energy would represent around 2% of the required funds.

The AAAA also mandated ECOSOC to organize an annual Forum on Financing for Development ("FfD Forum") to improve monitoring of the global SDG financing activity. Furthermore, it mandated the UN to compile annual Financing for Sustainable Development Reports (FSDR). The 2020 FSDR shows how Official Development Aid (ODA) is divided among the 17 SDGs.

According to that report, the most popular SDG for ODA grants is Goal 10 (Reducing inequality) which receives almost three times more ODA funds globally than would correspond to its even split share. Four other goals, namely Goal 2 (Zero hunger), Goal 3 (Good health), Goal 16 (Peace, justice, strong institutions), and Goal 17 (Partnerships for the SDGs), receive roughly the double of their natural ODA share. Two more goals, Goal 4 (Quality education) and Goal 9 (Infrastructure, industry, innovation) receive more ODA than their even split share. The three goals Goal 7 (Affordable and clean energy), Goal 8 (Decent work and economic growth), and Goal 11 (Sustainable cities and communities) receive just about the amount corresponding to their even split share. All the other SDGs receive less than their even split share. In other words, the even split share allocated to SDG7 prevents this SDG to receive more than the 2% of its funding needs through ODA.

Figure 34: Official Development Assistance granted to each SDG

Source: UN FSDR 2020[72]

The above analysis calls for some comments.

Firstly, ODA can only represent a small fraction of development finance affected to the SDGs. Given the large amount of SDG financing required, it is unrealistic to hope for ODA to cover more than a small fraction of it. 2% is, however, too low. ODA will be used with priority in SDGs that require public sector activities. Prioritising ODA in the struggle against inequalities and hunger, for better health, justice, and stronger partnerships, does not come as a surprise. The surprise is rather the small part affected to SDG1 (fighting poverty) and SDG5 (gender equality).

Secondly, the main role of ODA is to act as a catalyst to amplify private finance. Even to act as a catalyst, 2% seems way too low. The bulk (70%) of SDG financing is supposed to come from private capital. Private finance is especially important to finance those sectors that are close to the market. Private finance is expected to act in two forms, either as public private partnership projects (PPP, see section 3.2.5) where private partners act jointly with the public sector, or in form of equity and bonds to market-oriented activities (chapter 2.3). Activities

suitable for PPPs are e.g.: Infrastructure (SDG9), clean energy (SDG7), sustainable cities (SDG11).

Thirdly, as mentioned, some SDGs are more market oriented. These may require public finance to set up framework conditions and improve market access or for setting up green taxonomies (see section 2.2.1) or for sharpening the ESG tools used by public enterprises (see section 2.2.2) to channel institutional finance from pension funds and sovereign wealth funds towards green activities. From the financing point of view, these activities may not necessarily need high amounts of ODA, but even more private finance.

Finally, the AAAA and its predecessor conferences have identified the mix of finance for SDGs by stressing the importance of instruments such as domestic taxation, FDI, trade, technical cooperation, external debt reduction, systemic questions, and the whole complex of science, technology, innovation, and capacity building. Given the scarcity of ODA, cities might explore whether they can fill part of the finance gap by facilitating the creation and use of green finance (Section 2.1.1). Some of the relevant investment flows will be described hereafter as they are being monitored by international bodies.

1.2.2. Key Developments Impacting SDG Financing

Several SDGs contain specific provisions on financial flows in support of specific SDGs. Of paramount importance for the energy transition are the flows directed to fulfilment of SDG7, *Ensure access to affordable, reliable, sustainable and modern energy for all*. The relevant indicator is SDG 7.a.1, showing international (public or similar) financial flows in support of renewable electricity in developing economies. Note that this indicator only measures public flows and only towards the developing world. This indicator shows a clear peak in 2017. Since then, flows have substantially decreased. The biggest contraction is on hydropower which was at an exceptionally high peak in 2017.

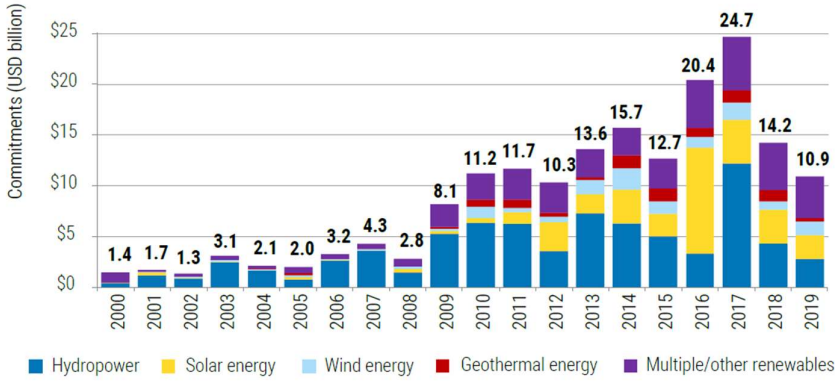


Figure 35: Annual international public financial flows toward renewables to developing economies, by technology, 2000–19

Source: Tracking SDG7: The Energy Progress Report, 2022[73]

If this picture is broadened to include also non-renewable energy, the analysis shows that the peak was even one year earlier, in 2016. The year 2017 has seen a peak of the share of flows directed to renewables of around 62%. This share has since come down to about 55%.

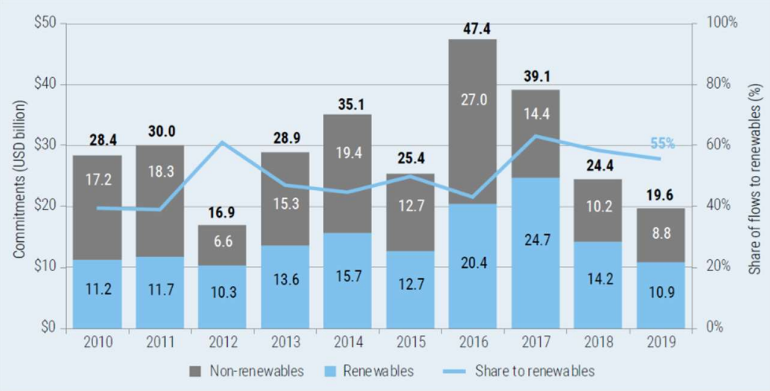


Figure 36: Annual commitments for non-renewables and renewables

Source: Tracking SDG7: The Energy Progress Report, 2022[74]

Both the above figures can be interpreted as indicating that public finance from the developed world to the energy sector of the developing world has started losing momentum since 2016.

The share of commitments by instruments shows the predominance of loans, even though their share has decreased to just over a half in the latest years. This mirrors well the analysis made in section 1.1.1. pointing to the relative lesser role of equity and of public capital in renewables, compared to the share of equity and public capital in energy in general. In other words: energy, including fossil energy, is regarded as activity suitable to be financed by public capital, whereas renewable energy is considered as activity to be financed by the private sector. This purely conventional attitude may be part of the problem to attract finance for clean energy.

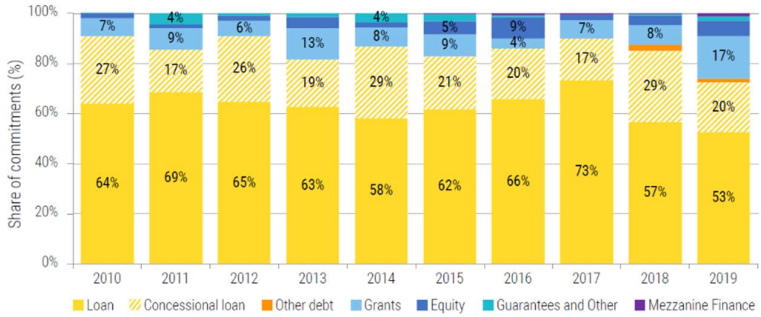


Figure 37: Share of commitments by instrument

Source: Tracking SDG7: The Energy Progress Report, 2022[75]

The above figures do not yet incorporate the more recent developments described below. The effects of these announcements will be seen only in the 2022 statistics or thereafter.

In October 2021, the United Nations High-Level Dialogue on Energy, aiming at setting the 2030 milestones for the energy transition towards carbon neutrality by 2050, assembled a great number of public and private representatives of the energy domain and committed to $400billion in new finance and investment from public and private sources[76].This event has been the first leader-level meeting on energy held under the auspices of the General Assembly for the past 40 years. Due to its timing, it served also to give input to COP26 taking place just weeks later.

Many commitments were announced at COP26 in Glasgow in November 2021. Before or during COP26, many participants announced their wish to end financing fossil energies. Chinese President Xi Jinping made this announcement at the 76th session of the United Nations General Assembly in September 2021.

Private investors provided more than 85% of investments in new renewable energy projects between 2013 and 2018[77]. The public sector has the role to enhance (catalyse, leverage) private finance. This role can be specifically expressed and measured as catalytic factor. The theory of catalytic financing is briefly explained in section 2.3.3. An example is presented in section 2.4.3 below.

The pledge to provide $100billion official development aid is being tracked in SDG 13.a.1. This target requires mobilization of the above sum from 2020 onwards in favour of financing climate change through all channels, including the Green Climate Fund (GCF). The figure below shows the funds mobilized by the GCF. An overview of the activity of the GCF is being presented in section 2.4.3 below.

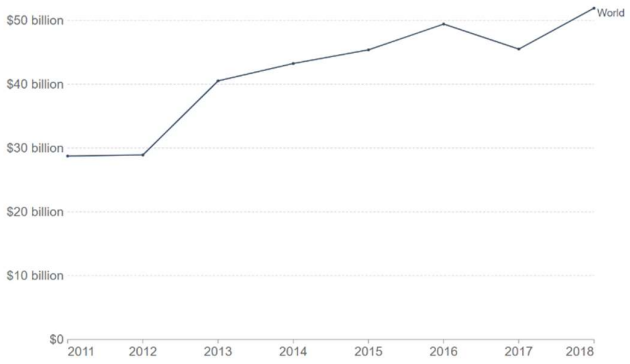


Figure 38: Green Climate Fund mobilization target of $100 billion

Source: Our World in Data[78]

Money invested in public private partnerships is tracked in indicator 17.17.1[79]. Any contractual arrangement between a public entity or authority and a private entity, for providing a public asset or service, in which the private party bears significant risk and management responsibility, is reported in this indicator. APEC economies having reported such activity are in particular China, Mexico, Viet Nam, Russia, Indonesia, Thailand, Malaysia and Papua New Guinea.

The total amount of funding for developing economies to promote the development, transfer, dissemination and diffusion of environmentally sound technologies is monitored in SDG 17.7.1. The figure below shows APEC economies having reported on this activity.

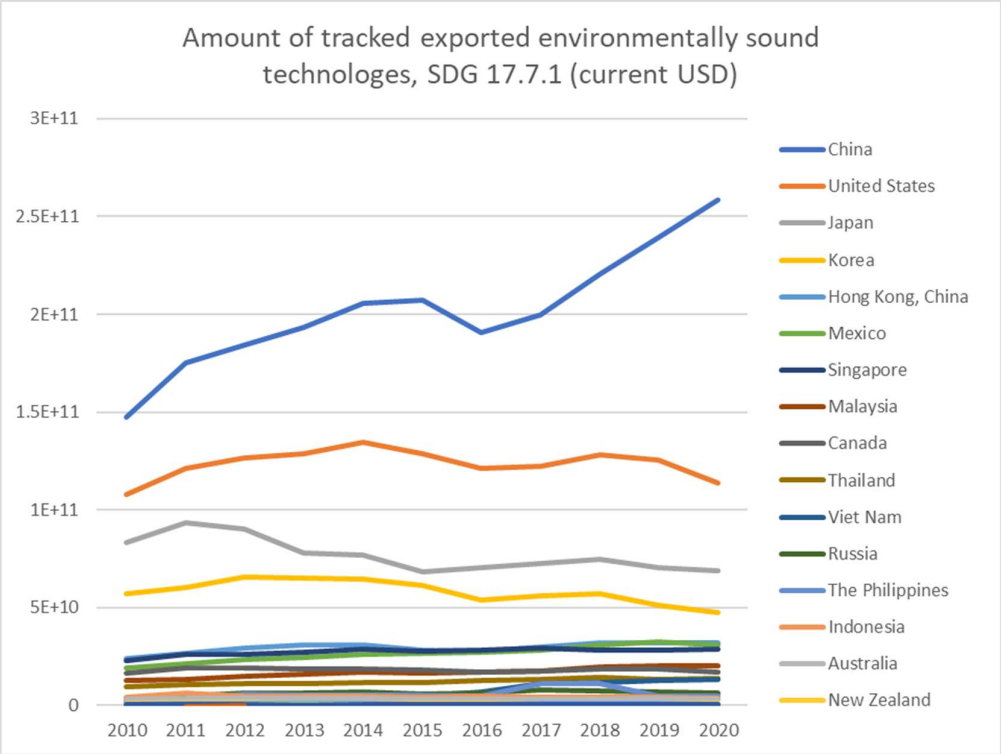


Figure 39: Promotion of Export of environmentally sound technologies

Source: APSEC, prepared with data from Our World In Data[80]

1.2.3. Impact of COVID-19 on SDG Financing

The pandemic called COVID-19 has been extensively described in the *APEC Integrated Urban Planning Report – Combining Disaster Resilience with Sustainability*. A planetary event such as a pandemic are likely to have a profound effect on the capacities of public and private actors to finance long-term goals such as the carbon neutrality or the SDGs. The present section summarizes and recalls a few key figures relating directly or indirectly to the impact of COVID-19 on SDG financing.

During the pandemic, by mid-2021, globally USD 16 trillion of fiscal support have been spent by governments to address COVID-19 measures. Of these, USD 2.3 trillion (38%) have been directed toward economic recovery, defined as long-term projects and measures to boost growth. Of these, USD 380 billion (2% of overall fiscal spending) were directed towards clean energy.

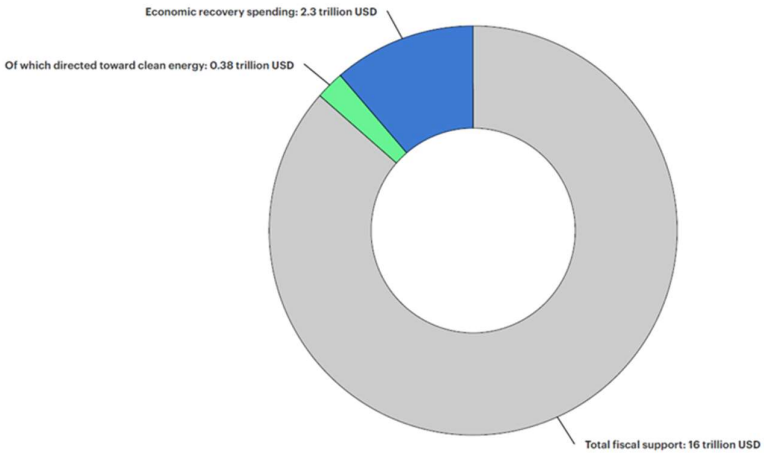


Figure 40: Fiscal COVID-19 stimulus share directed towards economic recovery and clean energy

Source: IEA[81]

The pandemic has indirectly impacted SDG financing by a cut in trade flows. It is known that COVID-19 has impacted international transport and international energy trade which is closely related to it. The figure below illustrates the extent of this impact and compares it to the impact of the pandemic on trade in other sectors. Energy trade fell by much more than average. Average trade reduction during the pandemic was one sixth (or 16%)[82].

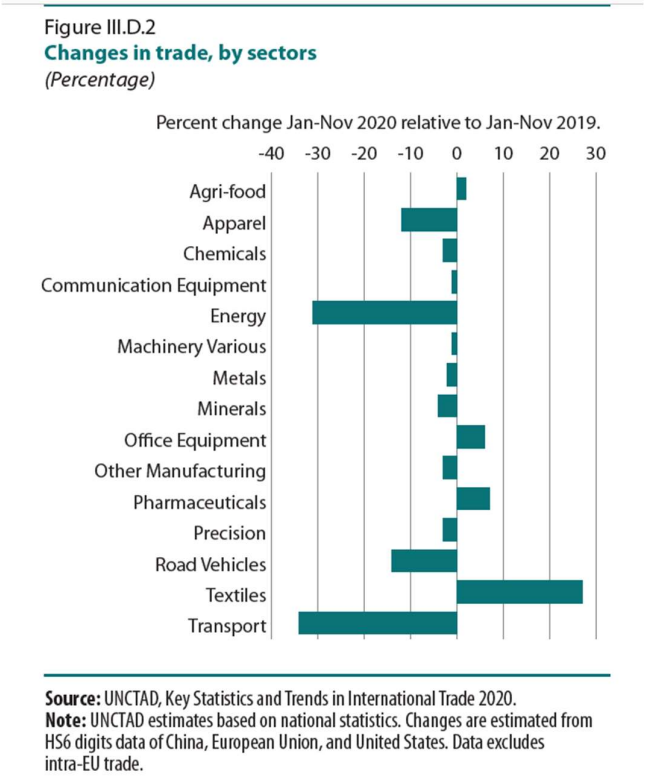


Figure 41: Changes in trade, by sector

Source: UN Financing for Sustainable Development Report 2021[83]

Equally well-known is that the pandemic has stressed public budgets and increased public debt. Compared to the 1997 Asian crisis or the 2009 financial crisis, the impact of COVID-19 is much larger, not only in absolute terms, but also in relation to GDP. During the first COVID-19 year, the world debt has increased by more than 15% of global GDP (right side scale) and is now approaching 100% of GDP.

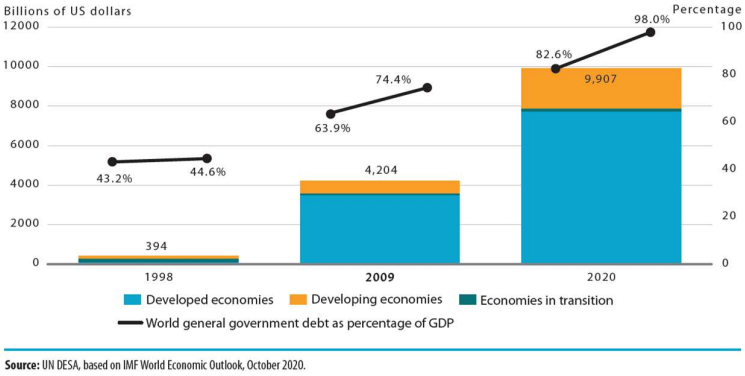


Figure 42: Increase in general government debt during past crisis

Source: UN Financing for Sustainable Development Report 2021[84]

Concerning the impact of the pandemic on renewables, most preliminary data sources point to the remarkable resilience of renewables. This is due to their cost having fallen in most cases below the cost of fossil energies. This explains why the share of renewables in capacity additions in developing economies has increased during the pandemic to 36.1% of total capacity increase in developing economies in 2020. This marks an all-time high. Renewables profited during the pandemic from being the cheapest energy source.

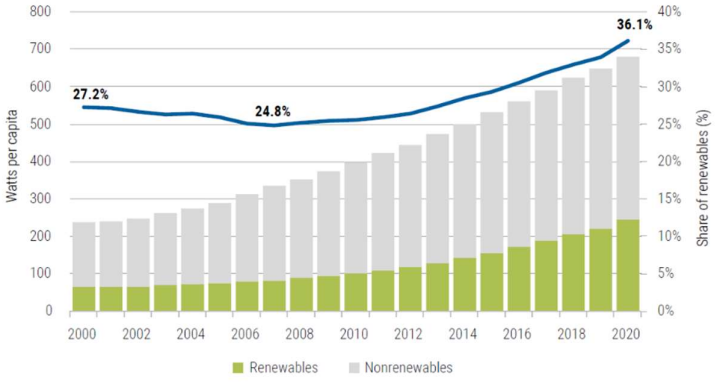


Figure 43: Annual per capita capacity additions in developing economies

Source: ESMAP/IEA[85]

COVID-19 did not have a negative impact on the path towards universal electricity access. If developments continue at growth rates like in the past, the universal electricity access might be attained to 97% or more by 2030 (see fig. below).

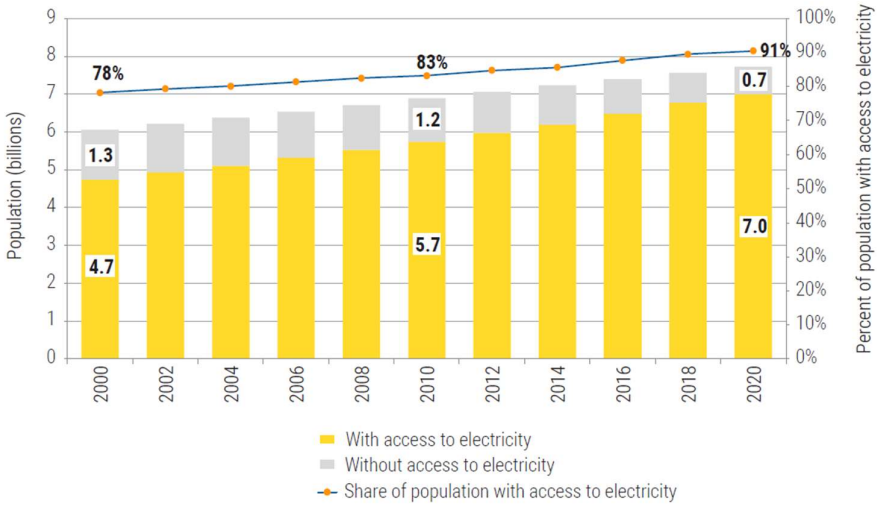


Figure 44: Development of access to electricity

Source: ESMAP/IEA[86]

COVID-19 did not have a negative effect on internet connectivity. It hit the world at a time (end 2019) when 3.7 billion people were still offline, unable to change to home office work or online teaching, while 4.1 billion people were already connected. By the end of 2021, 800 million people were newly connected, raising the share of the connected to 4.9 billion and diminishing the share of unconnected to 2.9 billion[87]. It can easily be extrapolated that by this speed, the world will be fully interconnected around 2028.

While connectivity as such plays an important role for reaching the SDGs, simple connectivity is, however, not sufficient. The type and speed of connectivity also matters, as mentioned e.g., in SDG indicator 17.6.1, Fixed Internet broadband subscriptions per 100 inhabitants, by speed. The evolution of broadband internet connectivity for APEC economies for any speed is shown in the figure below. Even when looking at broadband connectivity, the pandemic seems not to have affected any APEC economy's plans to expand connectivity.

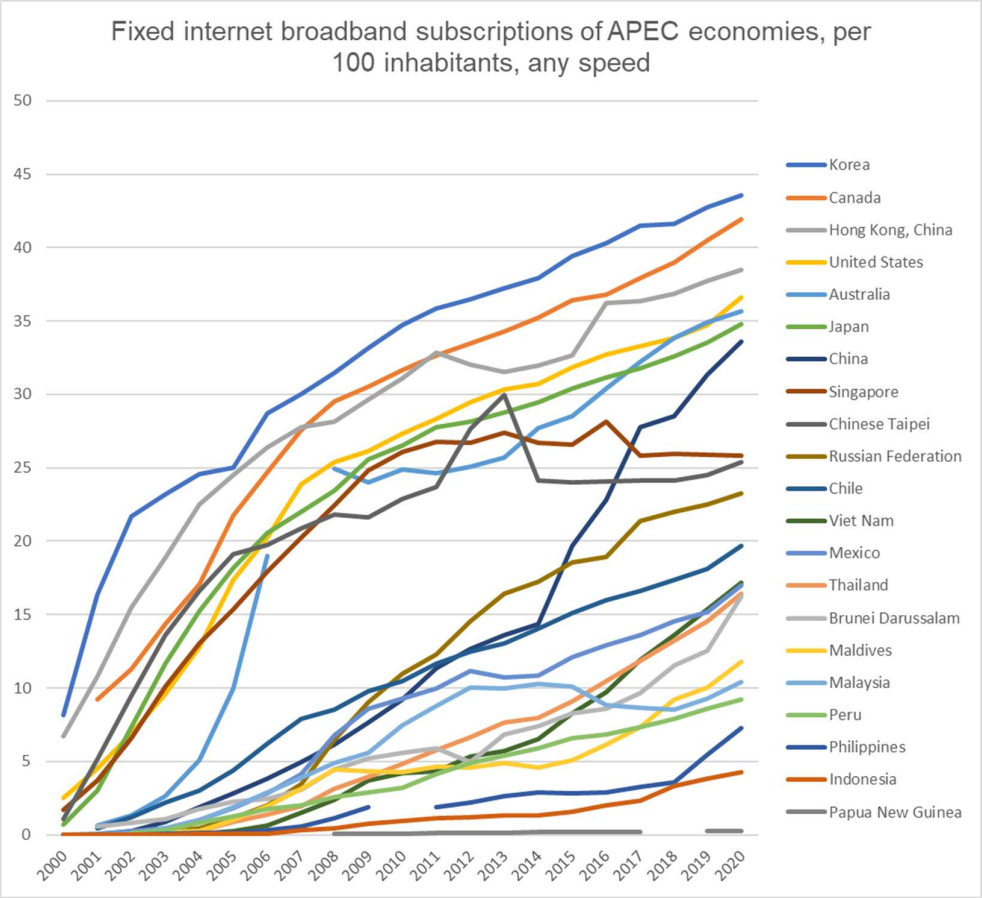


Figure 45: Fixed internet broadband subscriptions of APEC economies per 100 inhabitants

Source: APSEC, using ITU data

The pandemic is likely to have an indirect long-term effect on well-being through its effect on education and the creation of skills. COVID-19 strongly affected schools. UNESCO estimates that school closures during the pandemic have affected 1.6 billion learners, and that these will have lifetime earning losses of $17 trillion, equivalent of 14% global GDP[88]. Attaining SDGs requires appropriate skills. It is not yet known to what extent the pandemic will have affected the production of specific SDG-related skills, and whether the remediating strategy proposed by UNESCO, consisting of involving entirely new actors such as telecommunication industry, education technology industry, and media, into education, will have positive results on SDG-related skills.

The jobs market was severely hit by COVID-19. ILO states that during the first year of the pandemic, 225 million jobs or 8.8% of the total labour force were lost, resulting in $3.7 trillion labour income or 4.4% of global GDP lost[89]. Policies based upon temporary short-term working have helped to minimize the definitive job losses, replacing them by temporary work reduction and immediate restart after recovery. This may be the single most important resilience measure for overcoming the pandemic. It may have limited negative impact on financing SDGs.

Foreign direct investment (FDI) has been impacted by the pandemic. The UNCTAD first had announced that FDI fell by 42% due to COVID-19[90]. Later this figure was corrected to 35%, dropping from $1.5 to $1 trillion[91]. The SDGs that were most affected by the pandemic are shown in the figure below. Among them, the biggest investment losses were registered for

SDGs on water and sanitation (6), energy (7), infrastructures (9), cities (11), health (3) and the food and agriculture (2). It is premature to know how strong the loss of FDI in critical sectors such as energy, infrastructures and cities affects the global or APEC pathway to carbon neutrality.

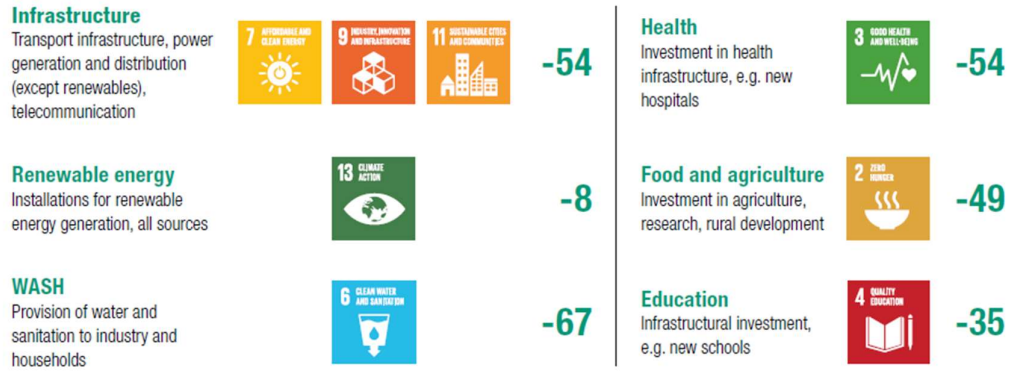


Figure 46: The pandemic impact on investment in SDGs 2019–2020 (Per cent)

Source: UNTAD World Investment Report 2021[92]

Recovery from the pandemic is to some extent based upon the same instruments as those that are used for the transition towards carbon neutrality. For both, recovery from the pandemic as well as transition towards carbon neutrality, sustainable or green activities can play the role of a new growth industry and hence help their economies to attain normal growth. The critical role of sustainable or green investment is needed to *transition from a niche to a mass market that fully integrates sustainability in business models and culture, leading up to 2030 and beyond*"[93]. To play this role, the market needs to address greenwashing and SDG-washing. The instruments of choice for fighting both are taxonomies (section 2.1.1) and the ESG principles (section 2.1.2).

Public pension funds and sovereign wealth funds (SWFs) have become key actors in sustainable recovery. They manage assets of $52 trillion and $9.2 trillion, respectively. Their potential is, therefore, enormous. More than 40 per cent of their assets are invested in publicly listed equities, making them "universal owners" with large shareholdings in companies across a wide range of sectors and markets. However, SWFs and public pension funds could do more to promote sustainability. Only 16 of the 50 largest public pension funds and 4 of the 30 largest SWFs in the world published a sustainable investment report in 2019[94]. Furthermore, public pension fund portfolios are often restricted to invest in developed economies. It has been pointed out in section 1.1.1 that an increasing percentage of sustainable investment should go to developing economies as their production and mitigation costs are lower than those of developed economies. The mentioned restrictions on SWFs and public pension funds are less the result of the pandemic than the result of prior regulatory and investment practices.

Insurance companies can contribute to sustainable development through their role as risk solution providers, as well as through their role as investors (with assets under management of more than $30 trillion in 2018). Climate change is one of the newly identified systemic risks for the world. Total economic losses from disasters globally were an estimated $202 billion in 2020, up from $150 billion in 2019, with about $190 billion resulting from natural catastrophes[95]. Section 2.3.4 describes one of the ways (re-)insurance can help to address natural catastrophes. Pandemics, contrary to natural catastrophes, are mostly insurable by economy-wide health schemes which work very differently from the insurances covering natural

disasters. The pandemic is not expected to cause an increase of climate disasters and similar natural catastrophes, and hence the financing capacity of insurances covering the latter is not expected to be directly impacted by the pandemic.

1.3. Political Frameworks

1.3.1. Glasgow COP26

Among the prime political frameworks are the conferences of parties (COP) of the UNFCCC. This short section is designed to give a relevant overview of the numerous outcomes of COP26 held in November 2021 in Glasgow. More information can be found on the official website[96].

The output of COP26 must be understood as comprising the following parts:

- A main document, the (relatively short) Glasgow Climate Pact of 13 Nov 2021[97],
- Specific precisions agreed on some articles of the Paris Climate Agreement, esp. Art. 6.2., 6.4., and 6.8. (See section 2.2.4 of this report for more explanations)
- 31 (voluntary) agreements of the UK presidential agenda on subjects such as Coal, Cars, Cash, Trees, Methane, Net Zero, Nature Based Solutions, CCS[98].
- Bilateral agreements such as the China-US agreement[99]

Concerning interruptions of the COP process caused by the pandemic, the Glasgow COP26-summit can be qualified as a relative success as it saw a record number of participating delegations and representatives of organizations compared to its predecessor conferences. Its major achievement is that Net Zero became the most frequently made long-term pledge. The NDC updates, however, have been seen as still insufficient. This was partly compensated by the decision to deliver NDC updates during 2022 and to have agreed to a more frequent updating of NDCs. The significance of updating the rules of Article 6, which the two preceding conferences failed to agree on, is described in section 2.2.4. The numerous voluntary agreements must be seen as achievements allowing to overcome the unanimity requirement and to channel and bundle the collective effort of public and private actors alike.

The relatively weak language in some areas of the Glasgow Climate Pact (e.g., on abatement of coal power, phase out of inefficient fossil fuel subsidies, or renewable energy) may be more of symbolic rather than of real importance.

1.3.2. APEC Leaders and Ministers Declarations

The APEC Leaders give guidance to the APEC community essentially through the Leaders and Ministers Declarations. The important declarations in the areas related to energy, urban development or sustainability are shown hereafter.

The 2021 Leaders Declaration contains a considerable amount of language on sustainability and inclusion. Most importantly, however, the Aotearoa Plan of Action is a comprehensive catalogue of actions related to the sustainability issue in general with focus on growth as a response to the pandemic.

2021 APEC Leaders Declaration

Our Commitment to Sustainability and Inclusion

In 2021, the world continues to confront unprecedented challenges posed by the impacts of climate change. We acknowledge the need for urgent and concrete action to transition to a climate-resilient future global economy and appreciate net zero or carbon neutrality commitments in this regard. We commit to work together to ensure that our economic and environmental policies are mutually supportive.

APEC has made some progress in strengthening the region's capacity to adopt renewable energy and other environmentally sound technologies, as part of sustainable energy transitions that reduce our dependence on fossil fuels. In this context, we will continue to work together to support energy resilience, access, and security in the region. We acknowledge the importance of stable energy markets, and supporting clean energy transitions.

Building on this, we commit to leverage APEC's role as an incubator of ideas and capacity building to tackle climate change. We will further integrate action on climate change across relevant APEC workstreams.

Aotearoa Plan of Action – A plan for implementing the Putrajaya Vision 2040

Strong, Balanced, Secure, Sustainable and Inclusive Growth:

Objective: "We will promote economic policies, cooperation and growth, which will support global efforts to comprehensively address all environmental challenges, including climate change, extreme weather and natural disasters, for a sustainable planet."

- *Evaluation of progress: APEC's growth and prosperity is achieved on an increasingly environmentally sustainable basis.*

- *Individual Actions: Economies, will implement policies consistent with their international obligations to advance environmentally sustainable and resilient growth, including by contributing to meeting APEC goals.*

- *Collective Actions: Economies will:*

    - *Cooperate in relevant APEC fora to develop, encourage and exchange best practice policies, and promote capacity building programmes, that address all environmental challenges - including climate change - and support sustainable growth, such as through:*

        - *. structural reform;*

        - *i. trade, including APEC's work on facilitation of trade in environmental goods and services;*

        - *ii. public finance, including tax policy and rationalising and phasing out inefficient fossil fuel subsidies that encourage wasteful consumption, while recognising the importance of providing those in need with essential energy services;*

        - *iii. sustainable infrastructure and transport;*

iv. promoting sustainable growth across sectors and the development of cost effective low and zero emissions technologies, sustainable finance and, if appropriate, carbon pricing mechanisms; and

v. ensuring energy security, access, reliability and resilience through energy transition.

- *Seek to deliver existing Leaders' commitments on energy issues: particularly to accelerate progress towards the 2030 target of doubling the share of renewable energy in the APEC energy mix, including in power generation, from 2010 levels by 2030; and to deliver a plan to reduce aggregate energy intensity by 45%, from 2005 levels, by 2035;*
- *Work towards the sustainable resource management of agriculture, forestry and marine resources and fisheries, including by implementing the APEC Roadmaps on Marine Debris, and Combatting Illegal, Unreported and Unregulated (IUU) Fishing, and commitments to combat illegal logging and associated trade;*
- *Further implement the APEC Disaster Risk Reduction Framework;*
- *Advance APEC's circular economy work; and*
- *Advance work on sustainable tourism.*

In 2014, the APEC Ministerial Meeting reiterated the aspirational goal for doubling the share of renewable energy in the APEC energy mix, including for power generation, set the same year by Energy Ministers, and also reiterated the aspirational energy efficiency goal decided in 2011. In the area of urbanization, the Ministers endorsed the APEC Cooperation Initiative for Jointly Establishing an Asia-Pacific Urbanization Partnership and established a cooperative network of sustainable cities in APEC economies.

2014 APEC Ministerial Meeting

<u>Energy</u>

53. We commend the implementation of the APEC Low-Carbon Model Town Project and the related promotion activities and the strengthening of the Energy Smart Communities Initiative under the Energy Working Group (EWG). We welcome the outcomes of the 11th APEC Energy Ministerial Meeting (EMM), including the establishment of the APEC Sustainable Energy Center in China, the promotion of the APEC LNG Trade Facilitation Initiative and the aspirational goal of doubling the share of renewables in the APEC energy mix, including in power generation by 2030. We reiterate our aspirational goal of reducing APEC's aggregate energy intensity by 45 percent from 2005 levels by 2035 and to rationalize and phase out inefficient fossil fuel subsidies that encourage wasteful consumption while still providing essential energy services. We acknowledge Peru and New Zealand for initiating voluntary peer reviews of inefficient fossil fuel subsidies that cause wasteful consumption and sharing their best practices, and welcome the commitment from the Philippines to undergo the review in 2015.

54. Recognizing that fossil fuel will continue to play a significant role in the energy mix of this region, in the medium to long term, we therefore reaffirm the importance of the clean and efficient use of fossil fuel. We encourage member economies, where there are

difficulties in quickly deploying alternatives to coal, to enhance cooperation in developing and applying clean coal technologies such as highly efficient coal-fired power plants and Carbon Capture Utilization and Storage. We support the safe and efficient development of nuclear power, which functions as a base load power source, in interested economies. We encourage member economies to create favorable conditions for trade and investment to support the LNG market in the APEC region, including by relaxing destination clauses.

55. We agree to facilitate trade in Information and Communication Technology (ICT) products by converging energy efficiency regulations and enhance public-private dialogue through the ICT product Energy Efficiency Convergence Forum, to avoid possible technical barriers to trade of energy efficient ICT products.

Urbanization

77. We note the outcomes of the APEC High Level Dialogue on Urbanization in August 2014. We endorse the APEC Cooperation Initiative for Jointly Establishing an Asia-Pacific Urbanization Partnership. We encourage more support for urbanization cooperation activities.

78. We welcome the APEC Policy Support Unit (PSU) study on Urbanization and Sustainable City Development, and task it to continue its study on regional urbanization. We encourage relevant APEC fora to incorporate urbanization-related topics into their work programs. We agree to set up a Senior Officials' Meeting (SOM) Friends of the Chair on Urbanization to guide future work in this field.

79. We commend efforts made in the implementation of the APEC Low-Carbon Model Town Project and the Energy Smart Communities Initiative under the APEC Energy Working Group, and instruct officials to explore pathways to sustainable city development and to a new type of urbanization that is green, circular, low-carbon and people-oriented, thus striking a balance between economic growth, inclusive social development and sustainable use of the environment and resources. We agree to establish a cooperative network of sustainable cities in APEC economies.

2014 APEC Energy Ministerial Meeting

14. Clean energy supply remains a priority in advancing sustainable development, ensuring energy security and adapting to climate change. We aspire to the goal of "doubling the share of renewables in the APEC energy mix, including in power generation, from 2010 levels by 2030." To attain this target, member economies will enhance cooperation, promote innovation in renewable energy technologies, so as to reduce costs and improve the competitiveness and sustainability of renewable energy in the energy market.

Instructions of the APEC Energy Ministers

15. We reaffirm the UN "Sustainable Energy for All" initiative and instruct the EWG through the EGNRET to develop the road map for the aspirational goal of doubling the share of renewables in the APEC energy mix, including in power generation by 2030; and, to attain this goal, cooperate with IRENA or other organizations to conduct research on the economic benefits and cost-effectiveness of utilizing renewable energy and integrating it into power grids so as to support R&D, innovation and commercialization of clean energy

technologies and to promote practical cooperation on renewable technologies, equipment and services among member economies.

The 2012 meeting was important for trade and investments as it endorsed the environmental goods list on applied customs tariffs providing reduction to a maximum of 5%. Besides that, the 2012 meeting created the Policy partnership on Science, Technology and Innovation (PPSTI), allowing for better cooperation with science and technology.

2012 APEC Leaders Declaration

Trade and Investment Liberalization, Regional Economic Integration

We reaffirm our commitment to promote green growth and to seeking practical, trade-enhancing solutions to address global environmental challenges. In 2012, we made considerable progress in this regard. We welcome and endorse the APEC List of Environmental Goods that directly and positively contribute to our green growth and sustainable development objectives (see Annex C). We reaffirm our commitment to reduce our applied tariff rates to five percent or less on these environmental goods by the end of 2015, taking into account economies' economic circumstances without prejudice to their positions in the WTO. By reducing tariffs on environmental goods, we will help our businesses and citizens to access important environmental technologies, which will facilitate their deployment, and use contributing significantly to our green growth and trade liberalization objectives.

Intensive Cooperation to Foster Innovative Growth

This year we have advanced these objectives by transforming the Industrial Science and Technology Working Group into a Policy Partnership on Science, Technology and Innovation (PPSTI) to bring together the three key groups of innovation stakeholders – business, government, and academia – to address common challenges, enhance innovation capacity. The PPSTI will also organize Innovation Technology Dialogues - a mechanism to explore and identify how emerging innovative technologies and related policies and instruments can address current challenges faced by APEC economies and what are the prospects for their application. We welcome the results of the first ever Innovation Technology Dialogue on nanotechnology for energy efficiency.

At the 2011 meeting, the aspirational goal of reducing energy intensity by 45% until 2035 has been adopted, and the call to rationalize and phase out inefficient fossil-fuel subsidies that encourage wasteful consumption has been reiterated.

2011 APEC Economic Leaders Declaration

Promoting Green Growth

We are committed to advancing our shared green growth objectives. We can and must address both the region's economic and environmental challenges by speeding the transition toward a global low-carbon economy in a way that enhances energy security and creates new sources of economic growth and employment.

We have advanced these objectives significantly in 2011. In 2012, economies will work to develop an APEC list of environmental goods that directly and positively contribute to our green growth and sustainable development objectives, on which we are resolved to reduce by the end of 2015 our applied tariff rates to 5% or less, taking into account economies' economic circumstances, without prejudice to APEC economies' positions in the WTO. Economies will also eliminate non-tariff barriers, including local content requirements that distort environmental goods and services trade (see Annex C). Taking these concrete actions will help our businesses and citizens access important environmental technologies at lower costs, which in turn will facilitate their use, contributing significantly to APEC's sustainable development goals.

We will also take the following steps to promote our green growth goals:

• Rationalize and phase out inefficient fossil-fuel subsidies that encourage wasteful consumption, while recognizing the importance of providing those in need with essential energy services, and set up a voluntary reporting mechanism on progress, which we will review annually;

• Aspire to reduce APEC's aggregate energy intensity by 45 percent by 2035;

• Promote energy efficiency by taking specific steps related to transport, buildings, power grids, jobs, knowledge sharing, and education in support of energy-smart low-carbon communities;

• Incorporate low-emissions development strategies into our economic growth plans and leverage APEC to push forward this agenda, including through the Low-Carbon Model Town and other projects; and

• Work to implement appropriate measures to prohibit trade in illegally harvested forest products and undertake additional activities in APEC to combat illegal logging and associated trade.

The 2010 meeting was important as it decided to create low-carbon communities in the region, which became known as low carbon model towns (LCMT) and facilitated the diffusion of climate-friendly technologies.

2010 APEC Leaders declaration

Under our green growth agenda, we will assess the potential for reducing the energy intensity of economic output in APEC economies further than called for in our Sydney Declaration in 2007, enhance work on meeting the aspirational goal in the Sydney Declaration of increasing forest cover in the region by at least 20 million hectares of all types of forests by 2020, and instruct our officials to take concrete steps toward this goal. We will also enhance our cooperation to address concerns with illegal logging and associated trade and to promote sustainable forest management and rehabilitation. We will implement policies to create new green jobs, technologies, and industries to enhance regional energy security, decrease environmental degradation and the effects of climate change, and promote sustainable growth. We will promote energy-efficient transport. We will increase the dissemination and utilization of environmental goods and services, reduce existing barriers and refrain from introducing new barriers to trade and investment in such goods and services, and enhance our capabilities to develop this sector, by prioritizing

work related to addressing non-tariff measures on environmental goods, technology, and services. We will rationalize and phase out inefficient fossil fuel subsidies that encourage wasteful consumption, while recognizing the importance of providing those in need with essential energy services, and review progress toward this goal on a voluntary basis. We will promote deployment of low-emission power sources - renewable, nuclear, and fossil fuels with carbon capture and storage - to make our energy supply cleaner. We will create low-carbon communities in the region. We will facilitate the diffusion of climate-friendly technologies, including through ECOTECH and capacity building activities. We will ensure the sustainable development of our oceans, seas, and coasts, including their resources, and the conservation of the marine environment.

The 2009 meeting was the first one to call for rationalising and phasing out fossil fuel subsidies that encourage wasteful consumption over the medium-term.

2009 APEC Leaders Declaration

Responding to climate change through transition to green economies also offers opportunities. We will ensure that efforts to address climate change are consistent with our international trade obligations. A key thrust in APEC's sustainable growth agenda is the APEC Environmental Goods and Services (EGS) Work Programme, under which we will develop and implement a set of concrete actions to support sustainable growth in the region, advance work to increase utilisation and dissemination of EGS, reduce existing barriers and refrain from introducing new barriers to trade and investment in EGS, and enhance capabilities of economies to develop their EGS sectors. We also commit to rationalise and phase out over the medium term fossil fuel subsidies that encourage wasteful consumption, while recognising the importance of providing those in need with essential energy services. We will review progress on this at our meeting in 2010. We will also take steps to facilitate the diffusion of climate-friendly technologies, including through economic and technical cooperation (ECOTECH) and capacity building activities.

The millennium meeting supported the Energy Ministers Meeting of the same year and supported the simultaneous pursuit of economic growth, energy security and environmental protection, and welcomed the new energy security initiative and the new implementation strategy.

2000 APEC Leaders Declaration

Attachment 1 – Directives of Economic Leaders

Directives of APEC Economic Leaders

The Directives in this attachment are in addition to those we have made in the body of our Declaration and in Annex 1. The Directives cover issues relating to trade and investment liberalisation and facilitation, and economic and technical cooperation, and issues arising from the APEC Finance Ministers process.

Trade and Investment Liberalisation and Facilitation and Economic and Technical Cooperation

- *We support the actions of APEC Ministers Responsible for Telecommunications and Information Industry in their Cancun Declaration which lays out a Program of Action and Principles, and we urge them to find mutually beneficial ways to build upon this work to help achieve the visions we have set out in Brunei this year.*

- *We welcome the message from APEC Energy Ministers from their meeting in San Diego this year and commend the commitments made in their Declaration. Recognising that energy is central to building the region's economic and social future, strengthening the marketplace and promoting clean and sustainable development, we support their simultaneous pursuit of economic growth, energy security and environmental protection. We welcome the new energy security initiative and the new implementation strategy and note that the latter offers important capacity building elements, including an option available by request from economies for on-site visits by facilitation teams to share experiences on implementation according to needs expressed by that economy.*

Based on the above declarations, APEC has been working at project level and realized a considerable number of relevant projects. For the present report, the APEC projects related to sustainable urban development have been divided into two categories: either projects relating to the Low Carbon Model Tows (LCMT), or to urban topics other than the LCMT.

Annex 1 List 1 (at the end of this report) gives the comprehensive list of the 41 APEC projects that have a relationship with LCMT. Annex 2 List 2 shows the 48 APEC projects that focus on urban topics but show no relationship with LCMT. This shows that LCMT has made up almost half the APEC projects related to sustainable urban development.

2. The Role of Green Economy and Green Finance

Green finance is defined by the flows directed to green economy. Green taxonomies delimitate the green sector from other activities. The taxonomy of China (since 2015) includes only activities that are undoubtedly green so that green bonds can be issued. Taxonomy of the EU (since 2019) is based upon technical screening criteria that allow including a wider range goods or services under certain conditions so that it can deliver the information for mandatory disclosure of enterprises. Since its inception by the UN in 2004, ESG was implemented in form of six Principles of Responsible Investment (PRI). The volume of PRI implementing assets worldwide has grown to more than $120 trillion by 2021, a multiple of the annual investment gap to attain carbon neutrality. Six major ESG rating agencies show high disagreement in ESG ratings. Contrary to credit rating, underpinned by probability of default, ESG rating lacks a similar underpinning. Separating genuine ESG improvement from greenwashing remains a challenge. ESG could to some extent be underpinned by SDGs and resilience indicators.

Increasing the attractiveness (profitability/risk ratio) of green investments requires either increasing their profitability, or decreasing their risk, or both. Carbon pricing is the instrument of choice to increase green sector profitability by eliminating *the greatest market failure the world has ever seen* (Stern Report, 2007). Yet, incentive carbon taxes have not mushroomed. It has been impossible to design WTO-compatible border taxes to prevent carbon leakage. Furthermore, incentive carbon taxes should be levied in market segments where there are alternatives to fossil fuels. Boulder (Colorado) gives the example of a successful local carbon tax that generates green finance. Compared to subsidies on renewables which amount to 0.5% of global GDP, the world pays four times as high direct fossil fuel subsidies and twenty times as high indirect fossil subsidies. While APEC Leaders called in 2009 to phase out certain fossil fuel subsidies, IRENA proposed to diminish fossil fuel subsidies by one third, while half of the remaining fossil fuel subsidies ($300 billion annually) should be used as source of green finance for clean energy. The least cost option to attain carbon neutrality is the emissions trading system (ETS). ETS or black certificate trading is a high-tech mechanism. It generates green finance to the extent its proceeds flow to green projects. COP26 created new trading mechanisms replacing the earlier Kyoto Protocol ones. For cities, high integrity voluntary carbon markets become an instrument to contribute towards carbon neutrality. Energy attribute or green certificates allow trading green energy. COP26 has created the possibility to link green and black certificates in a single compliance market. It is now possible set more ambitious goals to reduce CO_2 or to increase the renewables share knowing that the costliest measures can be financed by the international compliance market. Feed-in tariffs (FIT) are the most effective way to increase renewables and hence a powerful source of green finance. Their problem is their success. The too rapid growth of intermittent power sources has been a challenge for electricity grids. FIT used at local level can be an instrument of choice to increase the local renewables share. Power Purchase Agreements (PPA) are a generalization of FITs and can be combined with green certificates to increase the renewables share. For liberalized electricity markets, virtual PPA (vPPA) are the appropriate form. Public Private Partnerships (PPPs) are used by cities to fill funding gaps for green investments. Prerequisite for PPPs is, among others, the existence of a market for green infrastructure projects. Land Value Capture (LVC) is one of the most important instruments to finance Transit Oriented Development (TOD). It is analysed as a source of green finance to the extent that TOD, together with mixed zoning, diminishes energy consumption of daily commuting.

The overview of green financing instruments shows green bonds, the most popular instrument, showing strong growth. Green loans are bilateral and much less in volume. Green equity is important as it does not create debt and helps in de-risking. Environmental insurance has a huge potential but requires a clear legislative basis. Credit guarantees are the indispensable way to de-risk investment flows to developing economies.

Credit Risk Guarantee schemes are the instrument of choice to improve the risk-return ratio of investments. Financed by a third party such as a government agency, they protect the lender against default of the green project owner who pays a guarantee fee similar to an insurance premium. The optimal amount of the guarantee fee should depend on the lender, the borrower and the general economic context. Commercial banks play an important role for develop green projects. Their instruments include a combination of green credit, green bonds, green leases, green trusts, green insurance and green wealth management. The example of the Construction Bank of China (CCB) and its activities and instruments is presented in the text. Green bonds have also been used to finance the energy efficiency renovation of super-tall buildings in China. The example of the Qingdao Haitian Center T2 Tower Building shows how green bonds have helped overcome the finance gap to install ten new energy-efficient technologies. The increasing role of insurance for financing climate risks is shown by the example of Insurance Linked Securities and Catastrophe Bonds proposed by SwissRe. With the help of these new types of securities, which emerged after natural catastrophes of the early 1990s, it is possible to transfer tail risks which cannot be supported by a single company to the financial market which has much bigger capacity.

The Asian Development Bank (ADB) is one of the multilateral financial institutions that is active in financing carbon neutrality. It works primarily with governments but has also a strong arm for cooperation with the private sector. ADB is for certain cases a lender of last resort. ADB uses green finance to provide several categories of benefits to its credit takers. The cooperation takes different forms depending on the partner. ADB has also engaged itself in the Belt and Road initiative. The Asian Infrastructure Investment Bank (AIIB), created in 2016, has at present investments in 168 projects with an approved amount totalling USD 33 billion. Its sustainable energy strategy dates from 2017 and comprises improving energy access and security, energy efficiency, reduction of carbon intensity, management of local and regional pollution, catalysing private investment, and promoting regional connectivity. Energy comprises 34% of the bank's total financing. A cross-sectoral city strategy was added in 2018. AIIB has set a 50% target of climate financing against its total approved portfolio by 2025 and an earlier deadline of 1 July 2023 for its operations to be aligned with the goals of Paris Agreement. The Green Climate Fund GCF is the financing instrument of the Paris Climate Agreement. It has developed a strategy for cities attempting a paradigm shift. This is focusing on the relationship between local and central government level, centralization and decentralization pressures, how cities can take their demand side measures to improve their credit ratings, and supply side measures to mobilize private finance. GCF works with grants, equity, guarantees and concessional loans. De-risking is one of the prime tasks. For cities, there are 8 priority areas. Megacities need to be retrofitted, whereas small and medium size cities need to decouple new infrastructure from emissions. The Shandong Green Development Fund is an example of the Beijing-Tianjin-Hebei area. The GCF engagement of $1.5 billion will leverage $12 billion private funds, with a catalytic factor of 8, and bring about emissions peak in 2027 – three years ahead of schedule. The International Finance Corporation IFC is the World Bank's private sector support mechanism. $33 billion green loans are outstanding, of which $695 million have been granted in fiscal year 2020. The bulk goes to renewable energy. Energy efficiency, mitigation and more recently, adaptation have been added. In 2019/20 the

IFC granted a first-time green loan to Mexico for renewable energy. Green loans to China include solar power, green banking and agribusiness/forestry.

2.1. Green Labelling as Basis for the Green Economy

2.1.1. The Role of Green Taxonomies

Green finance is defined by the destination where the financial flows are directed to, in this case the green economy sector. To distinguish green finance from usual finance, it is, therefore, necessary to precisely define the green economy sector. The "greenness" of products can be defined in various ways. If we take the example of green electricity, greenness is defined by the production mode of the electricity, i.e., as electricity originating *from* a green or renewable energy source. This contrasts with green finance which is defined by the *destination* to which finance is directed.

Taking one step back, there are in fact different approaches to defining "green" or "sustainable" investment. A common approach is to define these attributes by type of economic activity. This is the approach of the taxonomies which e.g., define specific sectors such as photovoltaic energy as "green". Besides that, another approach is e.g., used by specialized rating agencies that give sustainability scores to enterprises. The result is a score, rather than a "yes" or "no". In this approach, a company, say an oil company, may receive high sustainability scores as specific sustainability measures may stand out with respect to peers, but the sustainability of the activity as such is not being analysed. One can also distinguish a third approach, consisting of creating maximum transparency of what an enterprise does or does not, supported by labelling, leaving it to the customer or the market to decide whether this is sustainable. The three approaches are not mutually exclusive.

The need to define the scope of the green economy has arisen from various sources. The first definitions came from individual companies that were keen to define their ESG (environmental, social and governance, see section 2.1.2) aspect more precisely. This gave rise to different bottom-up approaches to sustainable investment. Different approaches may cause confusion. Efforts have been made to structure the private bottom-up approaches. As an example, the Green Bond Principles launched by the International Capital Market Association (ICMA) in 2014 and revised since then[100] can be mentioned here. A characteristic of the Green Bond Principles is that they focus only on the specific projects for which they are issued and should, therefore, not be interpreted in relation to enterprise issuing them. A coal-producing electricity company can, therefore, issue green bonds for a solar project.

Another problem raises when a project improves attainment of one (or several) SDG(s) but simultaneously deteriorates one or several other SDGs. To answer this question, one has to decide about the principle whether SDGs can compensate each other (sometimes called weak sustainability) or not (also called strong sustainability). With 17 SDGs and 169 targets, it is near to impossible to have a project or an activity that has only positive effects on all of them. Some form of trade-off is necessary.

Over the years, several professional standard setting agencies have become active in this area, creating a certain confusion (see figure below). These agencies have in common to elaborate voluntary standards.

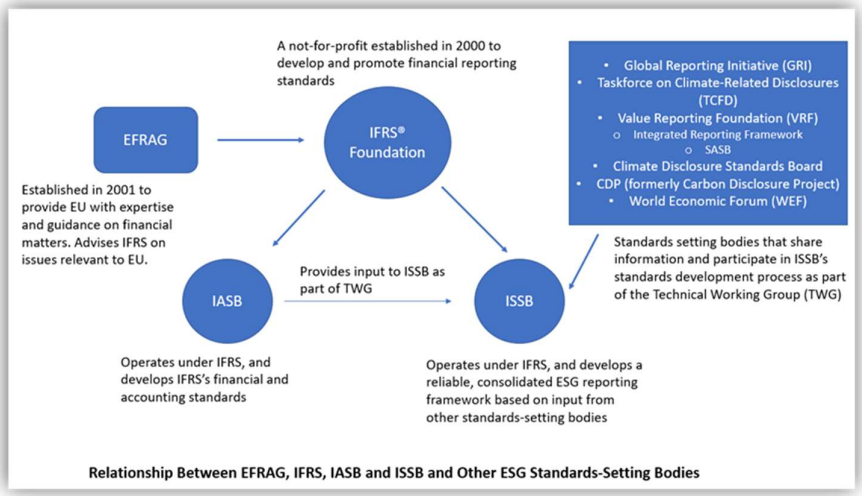


Figure 47: Relationship between sustainability setting standards

Source: Velocity EHS[101]

An important criterion for sustainability is the GHG emissions. In this area, the international framework[102] distinguishes between scope 1 emissions (made within the territory of a city), which may be corrected by taking into account scope 2 emissions (e.g., linked to an electricity grid producing electricity outside the city but consuming it within the city), and scope 3 emissions (incorporated in products and services consumed within a city). Scope 3 is very different from the other two as scope 3 implies not only accounting for upstream emissions originating from the raw materials and inputs, but also for the downstream emissions related to the life cycle of the product until its disposal. While the distinction between the three scopes has been elaborated in detail for GHG emissions, a similar distinction between sustainability effects of the organization (company or city) as distinguished from sustainability effects of the products and services of the organization can be made for many other substances. Take as example water. When analysing the water-sustainability of any organization (city or company), it makes sense to distinguish between the water used directly by the organization for producing its products, from the water used to produce the inputs and the water which its products are going to consume until the end of their life cycle.

As the distinction between products (goods and services) and production processes (operations) is relatively universal and can be made for all types of activities, a first step of harmonization of sustainability analysis can consist in answering the question: which products (if any) are always sustainable or unsustainable, and which production processes or operations (if any) are always sustainable or always unsustainable. A tentative answer to both these questions with application to listed companies is being given in the figure below. Both, the products and services as well as the operations mentioned are thought to be examples for the purpose of illustration. The figure serves also to differentiate the scope of taxonomies (relating to products and services) from the scope of ESG (relating to operations).

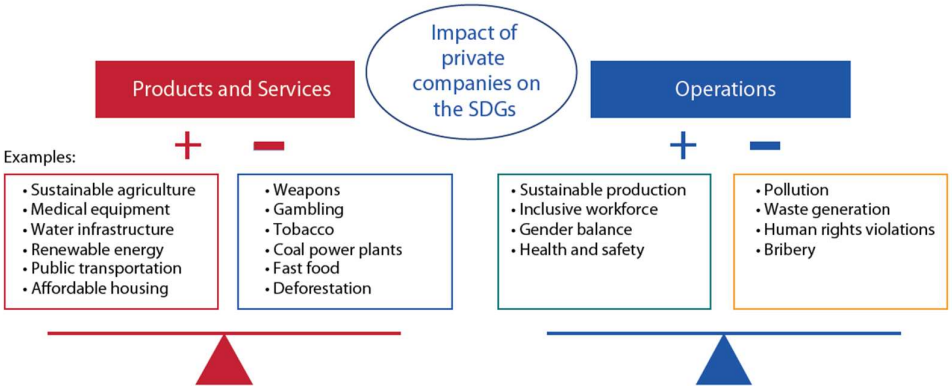


Figure 48: Framework to assess the impact of listed companies on the SDGs

Source: UN Financing for Sustainable Development Report 2020[103]

Now it becomes evident why regulators have felt the need to address the issue of defining "greenness" or sustainability. The approach chosen by regulators is the one of taxonomies. Such taxonomies are based upon top-down approaches. The two best-known examples of top-down taxonomies are the ones from the EU and from China.

In China, the need to define the scope of the green economy has been established in the China Green Bond Endorsed Project Catalogue which was first published by the People's Bank of China PBoC and the National Development and Reform Commission NDRC as a draft in December 2015[104] and has been revised since then. The latest version is the Green Bond Endorsed Projects Catalogue (2021 Edition) released by the PBC, the NDRC, and the China Securities Regulatory Commission (CSRC). The idea is to make this a mandatory catalogue for issuers of green bonds. The Chinese taxonomy is not enshrined in a specific legislation but applied by market regulators supervising green bonds. The Chinese taxonomy is based upon the Industrial Classification for National Economic Activities of China (ICNEA 2017). The Chinese taxonomy is based on a "whitelist" approach, allowing to include only those activities that are undoubtedly sustainable (e.g., manufacturing of solar panels or wind turbines)

The European Union also started elaborating a taxonomy in 2019 by reaching basic agreement on the future content of a Taxonomy Regulation (TR). The Taxonomy Regulation is applicable to three categories of actors. Member States should respect it when setting out requirements for financial market participants or issuers. Financial market participants offering products in the EU should respect it as they have to disclose taxonomy alignment of their products. Most broadly, any enterprise, financial and non-financial which is subject to the obligation to publish a non-financial statement must disclose at least the percentage of turnover, Capex and Opex aligned with the taxonomy. The European taxonomy regulation is based upon the NACE codes derived from ISIC Rev. 4 international classification of industrial activities. The EU Taxonomy is based upon the technical screening criteria (TSC) approach. This allows to consider larger parts of the economy as green or at least contributing to sustainability under certain conditions.

In detail, the European Taxonomy Regulation is working as follows: it describes economic activities that substantially contribute to any one of the following six environmental objectives and simultaneously "do no significant harm" (DNSH) to any of the other five objectives, and thirdly, comply with minimum international safeguards (e.g., OECD Guidelines on Multinational Enterprises[105] and the UN Guiding Principles on Business and Human Rights)[106]. The six environmental objectives are:

- Climate change mitigation
- Climate change adaptation
- The sustainable use and protection of water and marine resources
- The transition to a circular economy
- Pollution prevention and control
- The protection and restoration of biodiversity and ecosystems

Thereafter, technical group of experts (TEG) elaborated recommendations on detailed technical screening criteria for determining when an economic activity can be considered sustainable, and hence can be considered taxonomy-aligned[107]. Later, in 2020, the EU Commission published the first final version of the Taxonomy Regulation[108]. The list of activities contributing substantially to climate change mitigation or climate change adaptation and causing no significant harm to any of the other environmental objectives has been amended in June 2021[109]. Concerning the list of activities, it has been relatively easier to identify activities related to the first two environmental objectives, namely climate change mitigation and adaptation, than to the other four environmental objectives named above. In February 2022, the list of activities has been amended to take into account the specific role of natural gas and nuclear energy[110].

An example of how the technical screening criteria TSC approach is being implemented can be given for activities that are not undoubtedly contributing to climate change mitigation or climate change adaptation. These activities are considered as being in compliance with the taxonomy only if they satisfy strict criteria. Thus, the production of cement manufacturing, which is considered as a transitional activity, is recognized as substantial contribution to climate change mitigation if it satisfies the following specific emission thresholds or CCS conditions:

The activity manufactures one of the following: grey cement clinker where the specific GHG emissions are lower than 0,722 t CO_2*e per tonne of grey cement clinker; cement from grey clinker or alternative hydraulic binder, where the specific GHG emissions from the clinker and cement or alternative binder production are lower than 0,469 t* CO_2*e per tonne of cement or alternative binder manufactured. Where* CO_2 *that would otherwise be emitted from the manufacturing process is captured for the purpose of underground storage, the* CO_2 *is transported and stored underground […].*

The taxonomy is not only an analytical document, but it will eventually also be used to monitor the transition of all enterprises towards more sustainable economic activities. Companies with more than 500 employees will be required to disclose:

- the proportion of their turnover derived from products or services associated with economic activities that qualify as environmentally sustainable; and
- the proportion of their capital expenditure and the proportion of their operating expenditure related to assets or processes associated with economic activities that qualify as environmentally sustainable.

The top-down approach taken by China and the EU has inspired many other economies to develop taxonomies based on similar principles. In July 2020, the EU and China have initiated a Working Group on taxonomies co-chaired by both parties within the International Platform for Sustainable Finance (IPSF). The objectives were to identify the commonalities and differences in their respective approaches and outcomes. The work of this Working Group has been published in November 2021 and became known as the IPSF “Common Ground Taxonomy (CGT) – Climate Change Mitigation”[111].

Simultaneously, the UN Department of Economic and Social Affairs (UNDESA), in cooperation with the International Platform for Sustainable Finance (IPSF) elaborated a draft input paper on the G20 Sustainable Finance Working Group (SFWG) on improving compatibility of approaches to identify, verify and align investments to sustainability goals[112].

The need to define taxonomies has been recognized in several APEC economies:

- Japan is developing a taxonomy that is not legally binding.
- Korea has elaborated a draft taxonomy similar to the EU
- Indonesia is working out a taxonomy that is inspired by the EU taxonomy
- Viet Nam is elaborating a taxonomy similar to the EU model but based upon the Viet Nam Standard Industrial Classification
- The Philippines have started first thoughts on a taxonomy
- Malaysia has already published a Climate Change and Principle-based Taxonomy (CCPT) in April 2021
- Singapore has a taxonomy based upon the 'traffic light system' green (clear aligned), yellow (activities with pathways to becoming green) and red (activities that are inconsistent with the taxonomy).
- Thailand started discussion about the development of a taxonomy
- Chile is elaborating a taxonomy with technical screening criteria, similar to the EU
- Mexico has started discussing on a taxonomy
- New Zealand has published a draft taxonomy focusing primarily on agriculture
- Australia will most likely have a voluntary private sector-led taxonomy
- Canada is developing an industry-led taxonomy

2.1.2. The Role of ESG for Cities

Authored by Chitro Majumdar, RSRL, and Sergio Scandizzo, EIB

The ESG acronym refers to the integration of Environmental, Social and Governance factors in the decision-making process of a company. The environmental and social impact of corporate activities as well as their system of governance (ESG) was originally identified as the focus of firms' social responsibilities in the 2004 report "Who Cares Wins", prepared by a working group of several major financial institutions and published under the auspices of the United Nations Global Compact. The report argued that embedding environmental and social considerations in business decisions not only is good for society as a whole, but also positively affects companies' financial performance. A year later, the United Nations Environment Program Finance Initiative (UNEP-FI) produced the so-called Freshfield Report[113] which argued that ESG issues are relevant for investment decisions. These two reports provided the basis for the launch of the UN Principles for Responsible Investment (PRI) at the New York Stock Exchange in 2006 upon the initiative of UN Secretary General Kofi Annan who invited 20 large investors to promote the idea of responsible investment. It resulted in a voluntary charter of six principles or commitments by signatories which define responsible investment as incorporating ESG issues into investment analysis, ownership policies and practices, and seeking ESG disclosure.

Figure 49: UN Principles for Responsible Investment (PRI)

Source: PRI

The problem is that ESG was not well defined. This is still the problem today. An example of ESG definition which comprises the mostly quoted elements is given hereafter.

Figure 50: Components of ESG

Source: James Emanuel[114]

ESG is relevant for the Race to Zero, as it is for the 2030 SDG agenda. For private profit-seeking enterprises, ESG should not be misinterpreted to require enterprises to abandon their main purpose of seeking profit. Instead, ESG should be seen as a call to assess new and upcoming risks such as climate risks. ESG is inviting managers to take such new and upcoming risks into account and adjust investment strategies as early as possible. ESG can be seen as a methodology to look beyond short-term profits and put sufficient attention to future or long-term profits.

Over the following years, ESG integration has become an increasingly important part of public discourse on business and related regulatory requirements have developed and multiplied. Two questions are especially prominent within the debate: do managers have a duty to uphold ESG-related principles, and does ESG alignment affect, either positively or negatively, financial performance? The first question joins a long line of reflections on the nature and purpose of corporations from the so-called Berle-Dodd debate on corporate accountability (Macintosh, 1999) [115] to Donaldson and Preston's stakeholder theory of the corporation (Donaldson and Preston, 1995) [116]. The second question has generated over a relatively short time a monumental body of literature (Friede, Busch, and Bassen, 2015, Gillan,

Koch and Starks, 2021) [117] [118] and has been the subject of continuous discussions in particular within the asset management industry.

Over the last two decades, we have also witnessed the birth of specialised agencies that aim at fulfilling a similar role to the one performed by credit rating agencies: provide an independent assessment of the performance of a company along the environmental, social and governance dimensions. It appears, however that the methodologies developed by such agencies are still in the process of evolving towards a common standard as well as far from being able to capture all the relevant interactions between economic activities and environmental and social factors. While there is evidence that ESG ratings produced by different agencies for the same set of companies diverge substantially, such methodologies being proprietary and largely undisclosed, it is also difficult to establish to what extent they are theoretically sound and empirically robust.

A recent study has calculated the correlations of ESG ratings made by six major rating agencies that have developed and used bottom up ESG ratings. These six agencies are listed hereafter with their previous names (if applicable) and an abbreviation: Sustainalytics (SA), S&P Global (previously RobecoSAM, SP), Moody's ESG (previously Vigeo-Eiris, MO), Refinitiv (previously Asset4, RE), KLD (KL), and MSCI (MS).

	KL SA	KL MO	KL SP	KL RE	KL MS	SA MO	SA SP	SA RE	SA MS	MO SP	MO RE	MO MS	SP RE	SP MS	RE MS	Average
ESG	0.53	0.49	0.44	0.42	0.53	0.71	0.67	0.67	0.46	0.7	0.69	0.42	0.62	0.38	0.38	0.54
E	0.59	0.55	0.54	0.54	0.37	0.68	0.66	0.64	0.37	0.73	0.66	0.35	0.7	0.29	0.23	0.53
S	0.31	0.33	0.21	0.22	0.41	0.58	0.55	0.55	0.27	0.68	0.66	0.28	0.65	0.26	0.27	0.42
G	0.02	0.01	-0.01	-0.05	0.16	0.54	0.51	0.49	0.16	0.76	0.76	0.14	0.79	0.11	0.07	0.30

Table 3: Correlations Between ESG Ratings

Source: Berg and others[119]

The average correlation of ESG of just 0.54 does not show a high level of congruency of views between agencies. Not surprising, congruency is highest for environment, less for social and even less for governance. The ratings of four agencies (SA, MO, SP, RE) are overall better correlated among each other, whereas the ratings of two agencies (KL and MS) are quite different from each other and from the four above-mentioned ones. Especially problematic for the latter two are ratings on governance (G).

However, a more fundamental issue with ESG ratings is that it is difficult to understand what they are trying to measure. The websites of some major providers of ESG ratings yield the following intended objectives of ESG ratings:

- Monitor and analyse ESG performance of corporate, sovereigns and other entities (Moody's)

- Measure company performance on general and industry specific ESG topics with material relevance to financial outcomes (S&P)

- Measure a company's relative ESG performance, commitment and effectiveness across 10 main themes (Refinitiv)

- An organization's ESG score is, simply put, a numerical measure of how it is perceived to be performing on a wide range of environmental, social and governance (ESG) topics (Alva)

The above definitions all describe ESG scores in terms of a company's ESG performance. However, if we try to understand what ESG performance is, we have a hard time finding a definition that does not in turn involve ESG scores. One might argue that credit ratings suffer from a similar problem, as we use them to assess creditworthiness and, at the same time, we define credit worthiness in terms of probability of default, which in turn we measure with credit scores. This is, however, not the same situation, as the probability of default has a very precise mathematical meaning which we can define independently from credit scores.

Therefore, not only the way such ratings are derived suggests a fallacy of ambiguity, whereby a hypothetical construct may be treated as real, but it is also unclear what such hypothetical construct might be. Unlike credit risk ratings that aim to estimate an unobservable, but well-defined quantity (the probability of default), ESG ratings purport to measure companies' "ESG performance" or "ESG risks", without providing any ontological grounding for such concepts.

This indeterminacy is also reflected in the literature on the relationship between ESG and financial performance, as studies differ substantially in their choice of explanatory variable of interest for ESG performance (Friede, Busch, and Bassen, 2015) and provide scant theoretical grounding for such relationship. Not surprisingly, this looseness in definition also facilitates the spread of disinformation about corporate behaviour, the most prominent example of which is currently greenwashing (de Freitas Netto et al., 2020).

What is ESG performance?

What, then, is ESG performance? I argue that it is not just a loose combination of a disparate set of targets, from emission levels to recycling percentages, from labour laws compliance to gender equality measures, as looking at some of the rating methodologies mentioned in the above explanations could suggest. Rather, it is a measure of a company's contribution to specific public goals that are set at domestic or international level through the relevant political process. Two aspects of this definition are important. The first is the link of a company's activities to the pursuit of the common good, intended as something "proper to, and attainable only by, a community, yet individually shared by its members" (Dupré, 1993). The second is the identification of the common good as the result of a political process.

Cities as Green Investors and ESG subjects

Wherever cities manage infrastructures, cities take either the role of investors making long-term investment decisions, or of procurers and consumers of goods and services that are being procured on the market. In both these roles, cities can impact their progress towards sustainability.

If cities want to become more active and visible as green investors, they may improve their so-called SDG management, whereby ESG stands for environmental, social and governance performance. ESG is broadening the traditional commercial and financial performance with supplementary indicators for the three mentioned domains. ESG has been developed for improving the management of large private enterprises. ESG can be relevant to the management of cities.

Cities and municipalities are not profit-oriented entities. Instead of making profit, they pursue other goals. For them, ESG could in principle serve to clarify the goals they pursue. However,

the same is true for SDGs and their targets, so there is a kind of duplication between the ESG and SDGs. In fact, ESGs are older than SDGs, and SDGs and their targets have been negotiated and adopted at global level precisely in view of having a set of measurable ESG indicators which were missing before. Hence cities and municipalities should rather look at the more recent and more precise and more general SDGs and choose the ones they consider as important and implement them, rather than looking back at ESG. Concerning ESG, the cities should, however, note the above principle 4, by virtue of which investors may require cities to have ESG strategies so that they can receive funds from such investors. Regarding such investors, cities should be able to point to their local SDG implementation, underlining the superiority of local SDG implementation over an ESG strategy and, thereby, receive full recognition of the equivalence of SDG implementation with an ESG strategy. In short, ESG and the PRI act as a call for cities to implement local SDGs. This role should not be underestimated given the large number of international investors that have subscribed to PRI and hence to ESG, totalling now assets of 140 trillion USD. These assets should be put in relation with the investment gap of 5 trillion USD annually needed to finance the Race to Zero (see Chapter 1).

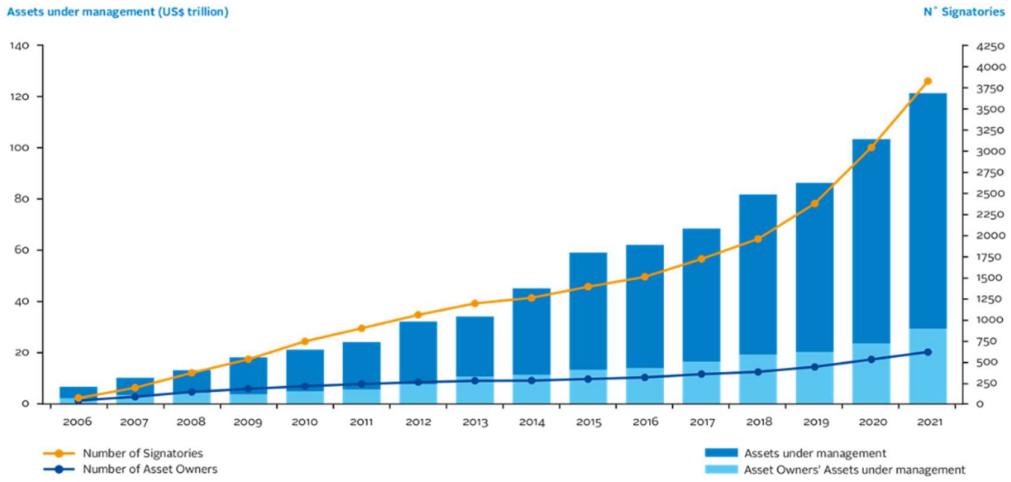


Figure 51: PRI growth 2006 – 2021

Source: PRI[120]

Sustainable development cannot be attained while disasters continue to undermine economic growth and social progress. Living in the urban areas has become distraught with many human-made disasters, e.g., urban flood, traffic congestions, health care emergencies, interconnectedness with OEM activities, etc. With the increasing accessibility to world-class infrastructures, India has, e.g., been into massive development activities, including 100 Smart cities. Usage of modern surveying tools and technologies like Aerial datasets and terrestrial Mobile mapping systems equipped with LIDAR and street view datasets are increasingly used for generating high resolution and highly accurate datasets for urban areas. There is an increasing demand by the urban community to move towards 3D datasets for creating geospatial datasets as it exists in the real world. The usefulness of 3D LiDAR-based mapping measurements for planning activities including various web-based tools to be used by the concerned line departments such as police, ambulance, fire, hospitals, traffic, are going to open up immense investment opportunities.

Climate challenge cannot be tackled without the participation of the public, and scientific organisation. All space agencies of the globe are well-positioned to help connect the public with the exciting research being undertaken on ways to address our energy and climate change problems.

Resilience is the capacity of a city or community to prepare for, respond to and adapt from dangerous and disruptive events, such as natural disasters, economic crises, demographic changes, health epidemics and others. Combining resilience with sustainable development has been addressed in detail the APEC integrated urban planning report (APEC 2021[121]). Given that resilience is a multi-dimensional phenomenon, local authorities should design and implement strategies for urban resilience that integrate environmental, social, economic and governance aspects. Thus, resilience becomes one of the supporting pillars or instruments of sustainability. In order to monitor progress in becoming more resilient, local authorities should use indicators that measure resilience along the dimensions outlined in the Disaster Resilience Scorecard for Cities[122] which is being applied by more than 4000 cities worldwide. Cities are complex systems having to combine environmental, social, economic, and governance threads with the criteria for disaster resilience. Across OECD, metropolitan areas cover only 4% of the land, but account for roughly half of the population and close to 55% of gross domestic product[123]. The world's urban population is now expected to grow from 3.9 billion today to roughly 6.3 billion in 2050.

As urban areas and the urban population continue to grow, so will the scale and impact of shocks and stresses upon them. These stresses include, but are not limited to, industrial structural changes (e.g., relocation or closure of a city's key firms), economic crises (for example, the global financial crisis of 2007/08 and the European debt crisis of 2009), population inflows/outflows; disasters (i.e., earthquakes, floods and hurricanes), disruption of energy supplies, and leadership changes. Large cities are particularly vulnerable to risks, once any sort of shocks to such complex systems will have significant economic, social, environmental and institutional repercussions. If cities concentrate risks, they also concentrate resources and opportunities to become more resilient. Urbanisation brings economic, social and environmental benefits to individuals and economies.

Cities concentrate resources – capital, infrastructure, social networks, skills and innovation – that can be invested in preventing, adapting and recovering from shocks and stresses. the city is both a territory from which risks can be assessed and a level of government in which action can and ought to be taken.

Chapter 1: Towards resilient cities	Resilience to what?	What are shocks, stresses, risks, hazards or disasters? Are disasters perceived differently by different stakeholders?
	Resilience at what scale?	How resilience should be addressed at the different scales (global, national, regional, local and household? How do these different scales interact?
	Why resilience?	What is resilience? Why are cities an arena for action? What are the qualities of resilient cities? What are the dimensions of resilience?
Chapter 2: Governing and measuring urban resilience	How to govern risks and build resilience?	What is risk governance? How can indicators contribute to more effective policy processes?
	How to measure the resilience of cities?	What are indicators and how are they useful? What do they measure: inputs, outputs, outcomes or processes? Can one measure urban resilience or does one have to resort to proxies? How do indicators relate to policy objectives?
	How to compose local sets of indicators?	How to design and use indicators adapted to the local context? What are the indicators that most cities should be concerned with?

Table 4: Fundamental questions on resilient cities

Source: Meerow and others[124]

Cities need to start with a risk assessment identifying shocks and stresses that the territory is or may be facing in the future. They must gather the relevant local stakeholders, in order to understand the local context and to build alliances that will later on facilitate implementation. By designing a resilience plan, cities can integrate risk management into different policy sectors, such as transportation infrastructure, land-use planning, education and employment. Cities can then implement resilience policies, under a clear and strategic long-term vision. Implementation has to be regularly evaluated, what can be done through policy indicators. Policy indicators can measure resilience levels and track progress of resilience policies.

The key global agreements, among them the New Urban Agenda, the Agenda 2030 for Sustainable Development and the Paris Agreement on Climate Change, have set the promotion of resilient cities as one of the main pathways towards sustainable and inclusive urban development

2.1.3. Selection of Green Technologies for Urban Carbon Neutrality

The previous sections have shown that green finance is defined by the activity into which finance is being channelled, which links green finance to the green economy and to green technologies. Green finance, contrary to usual finance, cannot be technology neutral. To complete the picture, some key green technologies must be outlined in a publication on green finance. The list below does not claim completeness.

Positive Energy Buildings

Among the technologies that are on the market are the ones related to plus-energy housing, that is housing that produces more energy than its proper needs. The first prototype of a plus-energy house has been developed in 1994 in Germany, in a location 47° north that has only about 1750 hours of sunshine per year and an average temperature of 11.7°C requiring almost 7 months of heating per year. This house produces between 4 and 6 times its energy consumption.

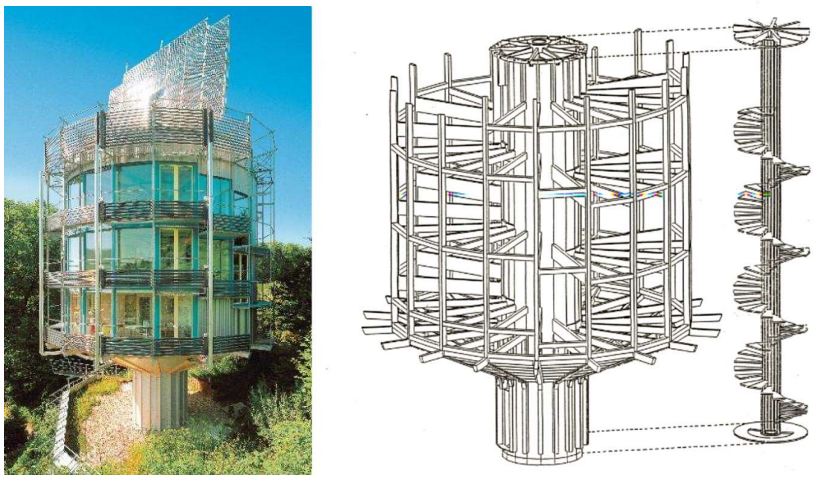


Figure 52: The positive energy prototype house

Source: Rolf Disch Archive[125]

Positive energy districts

Rolling out the positive energy building concept to entire settlements and districts has been accompanied by a diminution of the ambitions associated with it. Today the concept of zero energy building has been used to describe housing types that are energy neutral in annual average. The search for more sustainable habitats requires zero emissions buildings or better to be rolled out everywhere, with focus on neighbourhoods and districts rather than individual houses. In 2016 the proof of concept of positive energy districts has been made for a low-density low-rise district[126].

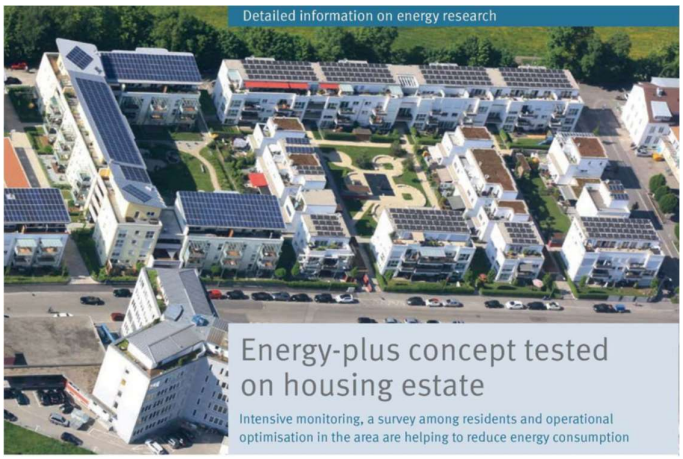


Figure 53: Energy-plus concept tested on housing estate

Source: BINE info paper

The next step is to test this concept for a high-density district. Some might believe that high density automatically means high-rise. This is not necessarily the case. If high density is defined as density above 15'000 inhabitants per square kilometre, then habitats such as the famous district of Eixample in the centre of Barcelona or similar neighbourhoods, being habitats without high-rise buildings, fit also within this definition.

Figure 54: Example of a high-density low-rise habitat: Barcelona

Source: Barcelonacheckin[127]

The task consisting of rolling out this technology to high-density districts implies bringing down the cost to the same level or lower than the cost of traditional housing. This is where

integrated design and planning play an important role, together with the effect of driving down the cost by greater production scales. The creation of low-cost high-density plus-energy neighbourhoods is a task that no individual firm or person can manage as it needs the active cooperation of urban planning authorities. As globally half of the buildings existing in 2050 have not been built yet, there is a great opportunity of doing this in newly built cities.

The shift of focus from individual housing to neighbourhoods and districts calls for sectoral planning, especially energy master planning in cities and municipalities. Energy master planning creates planning consistency among the city, its districts, neighbourhoods and individual building compounds. Cities are highly condensed places, concentrating 80% of global GDP, 70% of global GHG emissions and two-thirds of global energy consumption.

Solar irradiation map

One component of plus-energy housing is solar rooftop. To manage the roll-out of rooftop solar, cities can set up maps of solar irradiation. Hong Kong, China, has set up a solar map indicating in detail the solar intensity of roofs. Such a tool can be regarded as a key technology for developing the rooftop solar potential of cities.

Figure 55: Solar Map of Hong Kong, China

Source: EMSD Hong Kong, China[128]

Optimized building shape and block typology

Besides rooftop solar, building-integrated photovoltaic (BIPV) solar energy should take an increasing role in modern cities. Sometimes a distinction is made between BIPV – where PV is added in the design from the start – and building-added photovoltaic BAPV – where PV is added to a finished construction. For BIPV in newly built settlements, the basic shape of the building can still be chosen. For BIPV active solar building envelopes, a key factor is the ratio between external surface and inner volume. Among six different basic shapes of buildings, it has been found that the H-shape building scores best. The result is dependent on many context variables and has been sensitivity-analysed for commercial buildings in an urban context with warm climate on the example of Hong Kong, China.

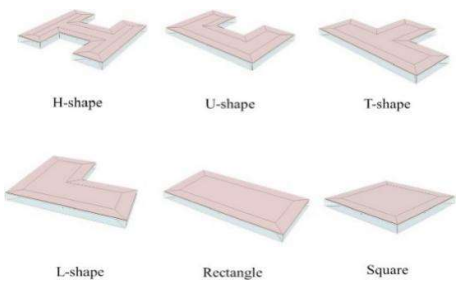


Figure 56: Optimization of different building shapes for BIPV

Source: Xi Chen and others[129]

In another study, the impact of urban block typology on building solar potential and energy use efficiency has been analysed for Singapore. The courtyard and hybrid block types are outperforming most other block types for their efficiency to use solar energy.

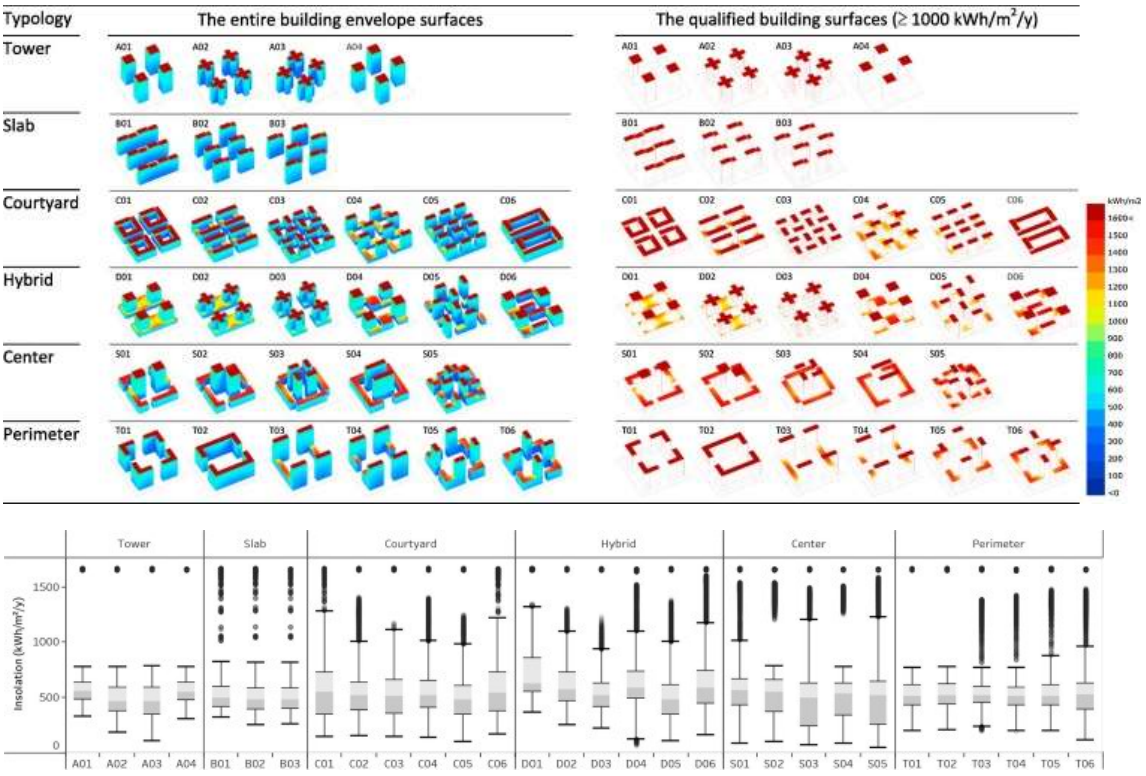


Figure 57: Optimization of different block typologies for use of solar potential

Source: Zhang and others[130]

District cooling

As the bulk of new urbanization is expected to take place in the global south where climate change affects peak temperatures, cooling is rapidly gaining importance. Coastal cities are favoured locations for district cooling as they can set up district cooling using the nearby seawater. District cooling is not only more energy efficient than individual cooling but also creates many side-benefits, as the project below shows. A prerequisite for reaping all these

benefits is adequate integrated urban planning. Pilot projects for district cooling exist e.g., in Hong Kong, China[131]. The Districts Energy in Cities Initiative[132] launched in 2013 by UNEP promotes district cooling and district heating. It includes four APEC members (Chile, China, Malaysia, Russia). The Asia-Pacific Urban Energy Association (APUEA) has been awarding the Global District Energy Climate Award since 2009. Among the winners of the 7th award of November 2021 there was a district cooling project (Zakito District Cooling, ZDC) in the Caribbean[133]. This is of particular interest to APEC as it can be transposed to small APEC islands. The 20-year macro-economic effects of the ZDC project are shown in the figure below and include side-benefits in 10 Deep Seawater Industries (DSI). Within 20 years of operation, the $45 million investment is expected to return forty times more macroeconomic benefits and to provide 400 permanent jobs. In APEC, Thailand is especially keen to scale up district cooling.

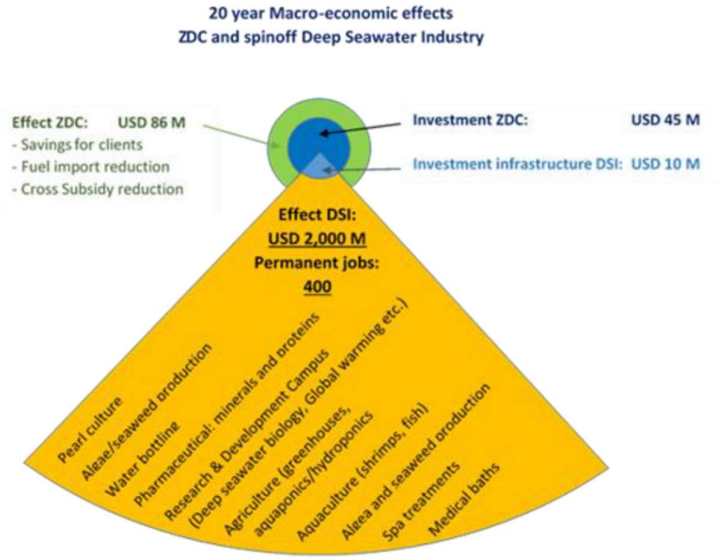


Figure 58: 20-year multisectoral benefits of a district cooling project on a tropical island

Source: Districtenergyaward[134]

Energy storage

The twin of renewable energy is energy storage. City-level energy storage in all its forms (thermal, electric, hydrogen) needs to receive high priority, including in urban planning. One way to store energy is thermal energy storage. Many cities realize geological underground heat storage, see the recent literature review[135]. Different types exist: Tank thermal energy storage (TTES), pit thermal energy storage (PTES), aquifer thermal energy storage (ATES), borehole thermal storage (BTES), latent heat storage (LHS), and thermochemical heat storage (THS).

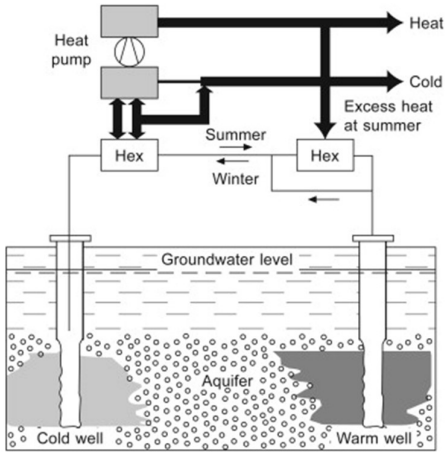


Figure 59: Aquifer thermal energy storage (ATES)

Source: Luisa F. Cabeza[136]

In APEC, all the cities or municipalities having thermal energy storage projects are in Canada and China; all of them are of the borehole or aquifer energy storage types.

Project location	Year of initial operation	Reference	Project scale	Main heat source	Back-up heating devices
BTES					
Okotoks, CA	2007	[47]	52 houses	Solar thermal	Gas boiler
Harbin, CN	2008	[48]	One house	Solar thermal	GSHP
Shanghai, CN	2012	[50]	One greenhouse	Solar thermal	None
Tianjin, CN	2013	[52]	270 houses	Solar thermal	GSHP
Ontario, CA[a]	2017	[55]	One greenhouse	Solar thermal	None
ATES					
Scarborough, CA	1984	[57]	One community	Waste heat	HP

Abbreviations: GSHP: Ground source heat pump, HP: Heat pump

Table 5: Thermal Energy Storage in APEC

Source: Tianrun Yang[137]

Electricity-related storage

The traditional form of electricity storage is pumped hydropower storage (PHS) which accounted for more than 95% of global electricity storage until 2015. This form of centralized storage is barely relevant for urban planning. However, IRENA has calculated that doubling the renewables share by 2030 will need a 17 to 38fold electricity storage increase[138]. Priority goes to decentralized battery energy storage. Community or building-scale stationary battery energy storage may require urban planning measures to guarantee safety and security. With higher renewables' shares becoming more and more common, this kind of storage may be necessary to overcome intermittency of renewables, which may lead urban planners to propose stationary storage targets for cities or for buildings. EV batteries or smaller are less relevant for urban planning. Another form of energy storage is hydrogen. Hydrogen is a purely

intermediary product, which is neither primary nor final energy, hence it is to be analysed as a way of storing, especially used in fuel cells.

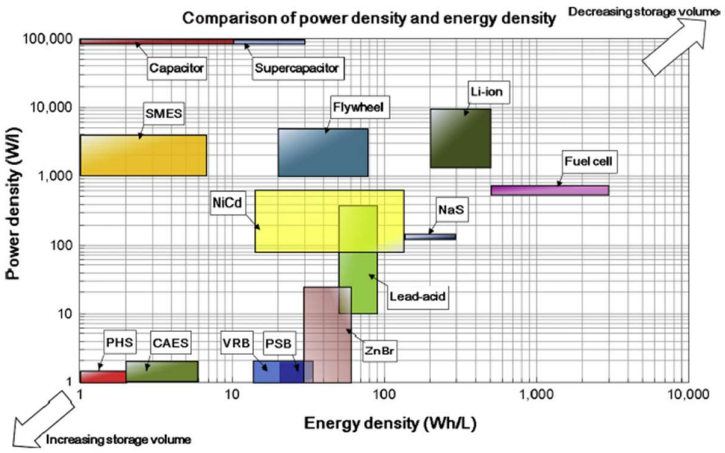


Figure 60: Comparison power density and energy density

Source: Luo (2015)[139]

The above figure can illustrate how technological progress improves electricity storage over time: at the bottom left corner is the traditional storage technology of pumped hydropower storage (PHS), whereas recent and future technologies will be found on the top right corner with increased energy and power density. To further enhance large-scale electric mobility, hydrogen fuel cells need to improve power density by a factor 10 to 100.

The new technology still under development is the so-called “supercapattery”, a merger between supercapacitors and batteries; this is not yet shown in the above figure. Their energy densities are said to be around 270Wh/kg[140], which, depending on their mass density, could be higher than the density of supercapacitors, with similar power densities to the latter.

The energy transition requires also large-scale seasonal storage at low cost and without need of rare metals. Among the possible candidates are HBr flow batteries that have energy densities of up to 200WsL^{-1} [141] and can be set up in modules to reach the necessary scale.

Figure 61: HBr flow battery for fix applications

Source: Australia Energy technology platform[142]

Improved energy efficiency for buildings

Besides renewables and storage, an important contribution to carbon neutrality will come from improved energy efficiency. Energy efficiency acts in a great variety of domains. Easy to introduce are measures destined to all new buildings. A key role is the building Certification

systems for new buildings, such as Leadership in Energy and Environmental Design (LEED), Building Research Establishment Environmental Assessment Method (BREEAM), passive house standards, or from retrofits of existing buildings (such as measures increasing the annual retrofitting rate). Building standards need to drive the process towards more energy efficiency in the building industry. The term “building standards” includes both, voluntary standards and mandatory regulations. These are complementary and play both an essential role. The voluntary standards may materialize as labels with categories (e.g., A to G), and regulations may then set the required minimum performance and the date by which it should be reached.

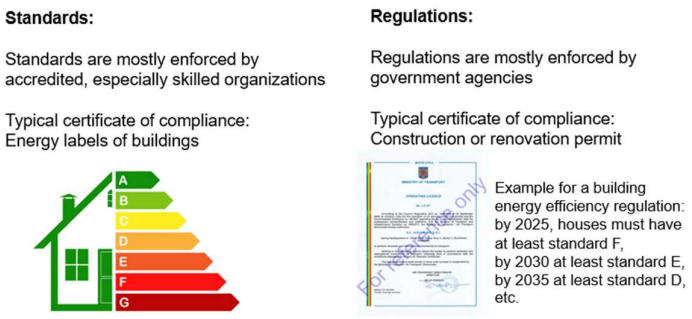


Figure 62: Complementarity of standards and regulations in building sector

Source: APSEC

Improved energy efficiency for appliances

Besides buildings, energy efficiency measures also concern appliances. The variety is very large. The phasing out of incandescent light bulbs and their replacement by LED is an example of such an energy efficiency measure. Cities may promote these technologies within their own premisses to enhance demonstration effects and awareness.

Building automation

Improving building automation and control systems is an area that has a linkage with the internet of things IOT and smart cities. Adaptive thermostats and lighting sensors are examples of such systems that are easy to introduce. Cities may promote these in their own buildings to create demonstration effects and raise awareness.

Wastewater to energy

Wastewater is one of the areas where the extent of existing infrastructure falls short of matching a closed-loop circular material flow. In many less developed APEC economies legislation exists, but is not, or cannot yet be, applied everywhere. Lack of awareness, scientific knowledge, technical skills, absence of infrastructure, institutionalized cost sharing mechanisms, and lack of specific finance instruments are the main reasons. These are generic to setting up the circular economy. The overarching objective of the circular economy consists of transforming waste to wealth. What this means can best be shown at the example of wastewater.

One of the old non-circular methods of wastewater treatment that can be found in many APEC economies is that households are collecting wastewater in an individual septic tank. Often placed under ground in a garden yard and covered for security reasons, this tank is not fully watertight. Inflowing wastewater will leak into the ground. Chemical processes will

produce methane set into the atmosphere. Every few years the tank is emptied from non-decomposed sludge. In the meantime, the leaked wastewater can diffuse into wider areas of the ground. If groundwater or freshwater sources are located nearby, these can become contaminated. Such contamination may cause Cholera outbreaks. APEC has seen several such local outbreaks, see *APEC Integrated Urban Planning Report (2021)*.

One of the elements improving this situation is for the city or municipality to install city-scale or community-scale wastewater treatment. In the simplest way, adapted to small rural communities, the sewage tanks will be emptied by a lorry more frequently and the wastewater emptied into a modular community-scale septage treatment plant which can set up rapidly (and urgently if needed) on any flat ground with minimal construction work. Receiving and treating 300m3/day, the plant generates sufficient biogas which, if captured and used energetically, can power a 100kW generator and neutralize 1500t CO_2eq/year mainly from avoided methane emissions. One module takes 500m^2 of land, modules can be placed next to each other if needed. The treated water is safe for environmental use in agriculture and gardening. The solid sludge can be transformed to biochar for a great variety of uses.

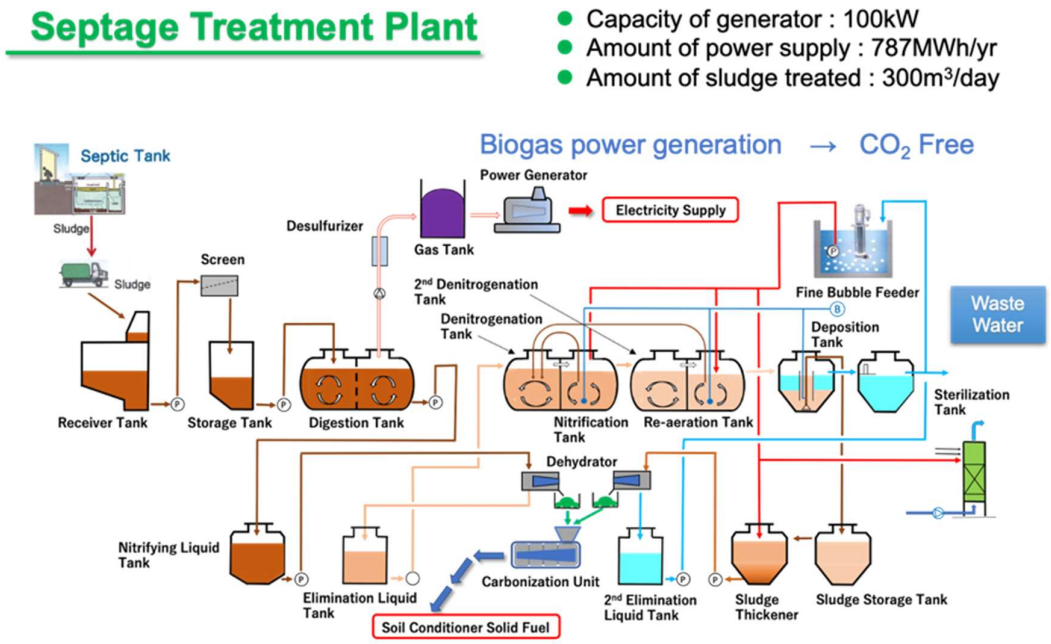


Figure 63: Flow chart of a modular community-scale wastewater treatment plant

Source: Daiki Axis

Once such a community-scale wastewater treatment plant has been set up, the community can gain experience and then start improving it with supplementary measures, such as: the refurbishment of the household's septic tanks preventing leaks, possibly replacing these by a system of wastewater canalizations connected to the plant, connecting the plant to the electricity grid (sometimes a long process) or to a local micro-grid (needs cooperation within the community), distributing the treated wastewater within the community or beyond, setting up production and use of biochar.

Electric vehicles

Among the new technologies to be mentioned are also electric vehicles (EVs). Urban planning can help rolling out electrification and smartness of individual electric vehicles.

Sometimes it is advocated that electric vehicles do not provide a great CO_2 reduction in a context dominated by coal-fired electricity such as is the case in the Northern part of China. This belief does not hold closer scrutiny. Field measurements made in 2019 have shown that even in regions where electricity is being generated by coal such as in the northern part of China, electric vehicles achieve an emissions improvement between 38% and 51% compared to gasoline vehicles, depending on standard assumptions, and that the electricity cost for charging EVs was 77% lower than the corresponding gasoline cost for the same distance travelled[143].

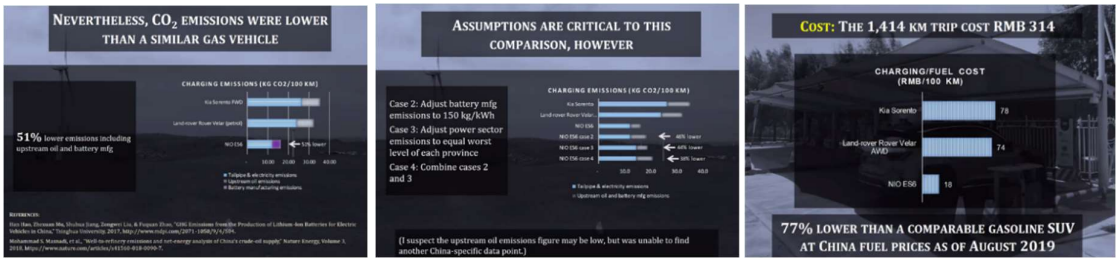


Figure 64: Emissions and cost comparison of fuels for EVs in Northern China

Source: GIZ webinar

EV-related technologies

In the area of individual EVs, several trends can be observed in this area:

- Electric vehicles
- shared mobility
- autonomous or self-driving vehicles (AVs), and
- wireless connectivity enabling communication between vehicles.

A development not yet visible is the development of PV integrated EVs. Integrating photovoltaic panels on electric vehicles has been shown to be a cost-effective and range-increasing element for all small and medium electric vehicles except for fuel cell vehicles[144]. The integration of PV can nowadays be done without diminution of aesthetic quality.

Figure 65: Invisible PV integrated EV

Source: PV Europe[145]

2.2. Increasing the Returns and Profitability of Green Investments

As was mentioned in section 1.1 above, the present decade is crucial for attaining the goal of the Paris Climate agreement consisting of *holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels*. The key success factor is sufficient global clean energy investment of 4 trillion USD per year allowing a decisive break-through of clean energy. The bulk of this investment should go to developing and emerging economies as these are currently building up new infrastructures and are in relative deficit of investment.

To increase green investment to the desired levels, it is important to lower the risk-to-profitability ratio of green investment. This means that either the profitability of green investments needs to be made higher, or risks associated to green investment need to drop.

The following sections 2.2.1 to 2.2.9 discuss ways to improve the profitability of green investments, either by eliminating systematic market distortions disfavouring green investments (sections 2.2.1 to 2.2.7), or by directly increasing the provision of green finance (sections 2.2.8 and 2.2.9).

2.2.1. Carbon Pricing to Eliminate Market Failures

The growing accumulation of greenhouse gases (GHG) in the atmosphere is described by economic analysis as the result of a market failure (also called market inefficiency, external cost, or negative externality). Climate change happens as the emission of greenhouse gases (GHG) is greater than the natural absorption capacity of greenhouse gases. Emitted GHG accumulate in the atmosphere, causing the greenhouse warming effect under the influence of sunlight. More than 70% of the greenhouse gas effect is caused by CO_2 emitted by consumption of fossil energy. The market failure arises as polluters, i.e., the economic agents who pollute the atmosphere, are not obliged to clean the pollutant from the atmosphere, nor are they obliged to pay someone else who would do the cleaning on their behalf, nor are they obliged to pay for damages caused by their pollution. This type of failure is called a market failure in economic science. Market failures lead to overconsumption of the specific goods. Economic analysis postulates that market failures should be eliminated by making the polluters pay. The famous Stern Review on the Economics of Climate Change (2007)[146] which was the first governmental report describing the economics of climate change, stated in its summary[147]:

Climate change is the greatest market failure the world has ever seen, and it interacts with other market imperfections. Three elements of policy are required for an effective global response. The first is the pricing of carbon, implemented through tax, trading or regulation. The second is policy to support innovation and the deployment of low-carbon technologies. And the third is action to remove barriers to energy efficiency, and to inform, educate and persuade individuals about what they can do to respond to climate change.

The review also recommends four areas of international cooperation:

- Emissions trading and linking emissions trading schemes around the world
- Technology cooperation, massive increase of support for energy R&D and deployment of low carbon technologies
- Action to reduce deforestation

- Adaptation policies to be integrated into development policies, and development of drought and flood resistant crops.

While some of the quantitative calculations and predictions of the Stern Review have been rendered obsolete by more precise and comprehensive research and data, the essential of its economic thinking is still valid, especially the key role of carbon pricing, also called internalizing of external costs (i.e., making the polluter pay), either through tax (today we would add: and through eliminating fossil fuel subsidies), emissions trading or regulation. In this section, the carbon tax (and fossil fuel subsidies) and the emissions trading are discussed, including as sources of green finance.

The question of setting a carbon price by way of taxing fossil fuels has been widely discussed in economic literature. In 1920, the English economist A. C. Pigou proposed what today is called an incentive tax (or Pigouvian tax) with the sole purpose of incentivising consumers to discard a good causing external costs (e.g., pollution) in favour of a good not causing such cost[148]. In 1972, Baumol[149] has shown that to be applied, firstly pollution standards reflecting tolerable pollution levels should be set, followed by the incentive tax to be set at a level that can empirically be shown to achieve the agreed standard. In 2015, the Paris Climate agreement has set such standard which it expresses in terms of warming pollution: Global warming should be kept *to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels*. In its Net Zero by 2050 Roadmap (see section 1.1), the IEA has spelt out a pathway to transform the global energy system to remain within the set limits of global warming and shown that it is a pathway to prosperity, and not to austerity.

The IPCC shows (see figure below) how a global CO_2 price can diminish emissions. If a global CO_2 price was set by raising a 20 USD/tCO_2eq tax, the resulting emissions mitigation can be seen from the figure below. The blue parts are already profitable without the incentive tax. Under the 20 USD/t CO_2eq tax, the blue and the yellow parts of the bars could be mitigated. For individual economies, locations or cities, the numbers shown in the figure might be different. Some technologies or options are shown in grey, which means that they cannot be quantified without specific hypotheses. Among these are light and heavy duty EVs. Further above (section 2.1.3) it has been shown that even in areas heavily dependent on electricity from coal, light EVs are emitting less CO_2 than corresponding gasoline vehicles, that the exact amount depended on specific hypotheses and situations, and that electricity per km travelled is also less expensive than gasoline. This means that in China, a gasoline tax is not the decisive factor for enhancing market penetration of light EVs. More important factors are the proximity and availability of charging stations and their charging speed, the interoperability between charging stations, and the amenities around charging stations. These are precisely those factors whose development can be influenced by the cities.

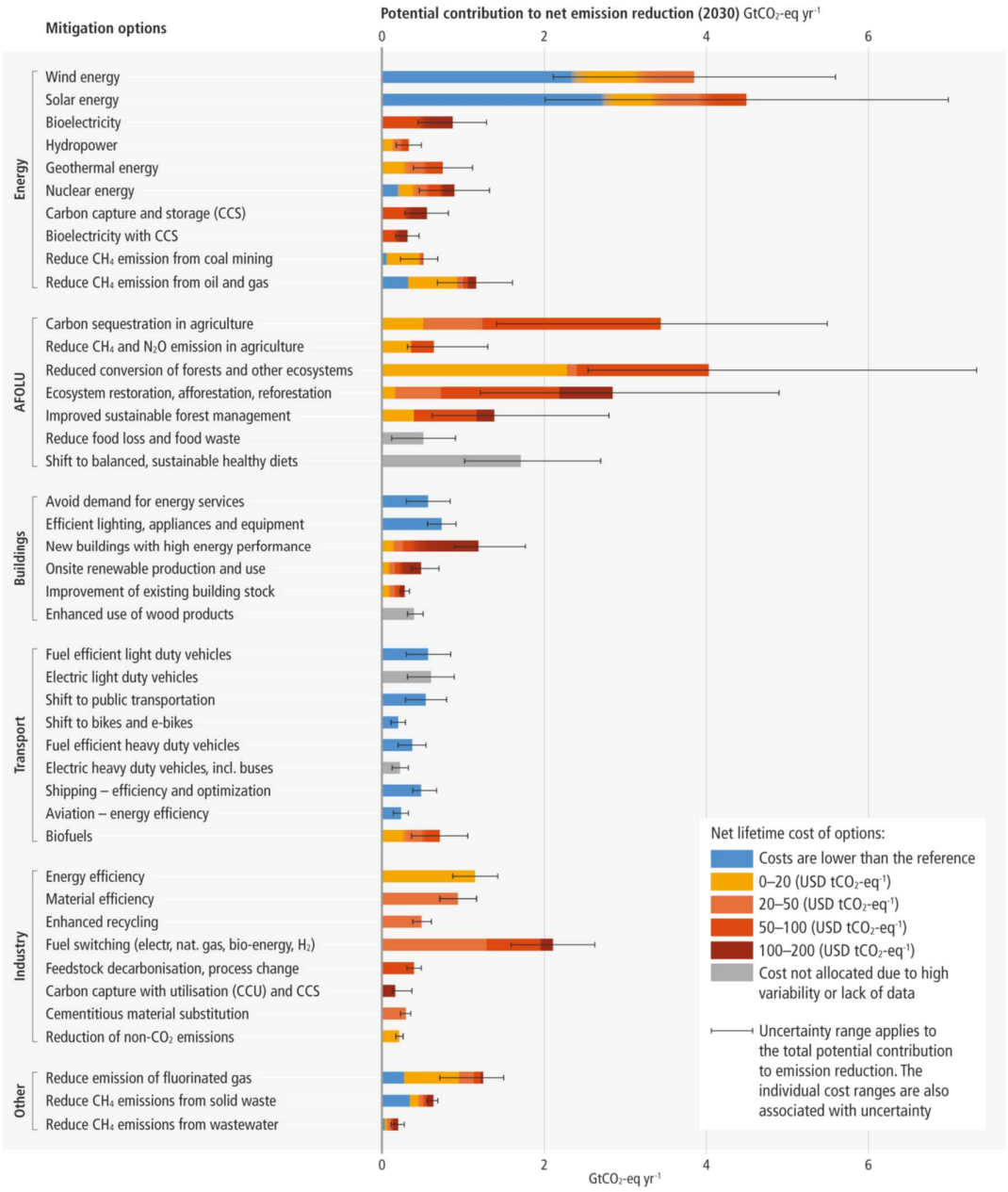


Figure 66: Mitigation options and their estimated ranges of costs and potentials in 2030

Source: IPCC AR6 WGIII Summary for Policymakers April 2022

2.2.2. Carbon Tax

A carbon tax is the instrument of choice to set a carbon price. The advantage of a carbon tax is that the resulting CO_2 price is relatively stable and predictable, compared to the relatively

volatile carbon price resulting from other carbon pricing methods such as emissions trading (see further down). In the above figure, each option's mitigation, expressed in Gt CO_2eq, should be put in relation with the current annual global emissions of around 36Gt CO_2. The sum of all options would eliminate all emissions. To drive the transition towards zero, carbon taxes could be steadily increased, according to a long-term schedule announced in advance, over a period of 30 years until 2050, to a level between 100 and 200 USD/t CO_2eq, allowing investors to prepare themselves well in advance.

The main challenge of raising carbon taxes is the impossibility to protect against carbon leakage. Carbon leakage is the delocalization of industries to jurisdictions that do not levy carbon taxes and hence get a relative competitive advantage. The higher the carbon tax, the stronger the carbon leakage. If a carbon tax is sufficiently high to change behaviour of economic agents, its main effect would be to cause delocalization of industries towards carbon tax heavens, thereby missing its target to diminish emissions. To avoid carbon leakage, the simplest way is to introduce a border tax proportional to the carbon footprint of imported goods, thus maintaining a level-playing field. However, such border tax would not comply with the relevant WTO rules that date back to 1947, decades before the carbon leakage problem was known. Even the current WTO Doha Round (or development round) started in November 2001, years before the adoption of the 2015 Sustainable Development Agenda by the UN. Its mandate under the trade and environment chapter is far from including even a hint that carbon leakage could be a problem[150].

The fact that it has not been possible to protect against carbon leakage prevents formation of consensus for carbon taxes. Still, some small steps have been taken to introduce carbon or similar taxes at regional level. The EU has introduced a minimum energy taxation in its energy taxation directive back in 2003 and has been revising this directive in 2021 as part of the European Green Deal (EGD)[151]. The EGD also includes a Carbon Border Adjustment Mechanism (CBAM) preventing carbon leakage. This mechanism is linked to the emissions trading system (see section 2.2.4 below) and could in this form be compatible with WTO rules.

Alternatively, another strategy to prevent carbon leakage in a WTO compatible way is to create a label of all the environmentally friendly goods and services, to reach mutual recognition on the set of these goods and services, and to (re-)negotiate bilateral (Free) Trade Agreements with trading partners on giving these goods and services a better treatment than to non-labelled ones. In this context it is of help that the relevant Multilateral Environmental Agreements (MEAs) such as the Paris Agreement have almost universal membership so that almost any negotiating party may feel bound by MEA provisions. APEC has made an important step in this direction in creating better conditions for clean goods in 2012 when APEC Economic Leaders endorsed a list of environmental goods and abolished tariffs on them[152]. The effects have been positive: Between 2012 and 2019, global and intra-APEC trade in the products on the list increased by 6.4 percent and 7 percent, respectively. The relative disadvantage of abolition of tariffs as compared with carbon taxes or a CBAM is that this does not generate any green finance.

It would be wrong to blame only the WTO for the relatively weak global role of carbon taxes. Another, possibly more important obstacle of incentive carbon taxes is the inelastic demand curve of fossil fuels. Taxation of inelastic demand mainly creates fiscal revenue but has little impact on demand. This effect is the exact opposite of what the incentive tax should be, namely, to impact demand and creating no fiscal revenue. Inelastic demand is the situation in which consumers have no substitutes (still largely the case for fossil fuels, albeit decreasing and fortunately so), whereas elastic demand is a situation in which they can easily substitute one product for another. The figure below shows the difference between inelastic demand and elastic demand. In an inelastic demand situation, if the price (for whatever reason) increases

from $15 to $20, demand decreases from 90 to 80 units and the resulting consumer payment or producer earning increases from $1350 to $1600. In an elastic demand situation, the same price increase results in demand response of 120 to 50 units, and the resulting consumer payment or producer earning decreases from $1800 to $1000. This explains that gasoline taxes of up to 50% raised in some places over the world can be used as fiscal revenue, mostly to finance highways or similar infrastructures, with only a marginal diminution of fuel consumption. On the other hand, it also shows that carbon taxes should be privileged in elastic demand situations. Demand elasticity also explains why producers in elastic markets easily make discounts: lower prices earn them much more due to strong consumer response.

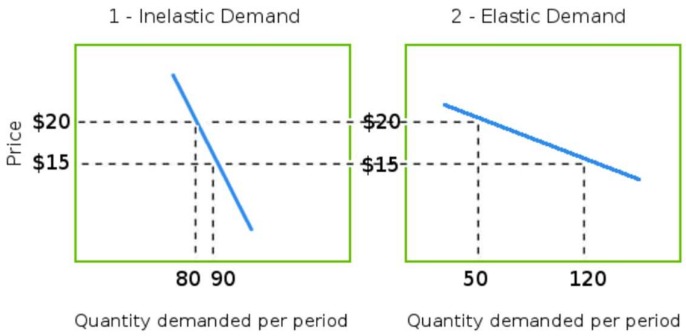


Figure 67: Effect of price changes in inelastic and elastic demand

Source: Palomar[153]

The lesson to be learnt from the above is that as long as there are no alternatives to fossil fuels on a given market, carbon taxes should be limited to a few percentage points of the price, and that during this period, their proceeds should first of all be spent to green projects (i.e., they should be used to generate green finance) which increase availability of non-fossil alternatives in view of making the demand curve become more elastic. Once alternatives exist, carbon taxes can start rising in those market segments where these alternatives exist.

Boulder (Colorado) shows that cities are ideal places for experimenting with carbon taxes. This city was the first US city to have introduced a carbon tax back in 2006[154]. The Climate Action Plan (CAP) Tax is a small (0.03cts/kWh) tax on electricity bills, differentiated between households, commercial consumers, and industrial consumers, yielding around 1.8 million USD per year spent on diminishing the city's GHG emissions such as: direct cash assistance to homeowners, landlords and businesses to fund energy efficiency upgrades, development of local solar energy projects, expansion of city transportation electrification projects and city-owned electric vehicle charging stations, regulation and building codes, policy and regulatory reform, partnership and international collaboration. The initial tax rates of 2007 have been slightly adjusted in 2009. In its current version it is limited till 2023. Authorities request voters to approve an extension to 2040 and merging it with the Utility Occupation Tax (UOT) which funds the city's partnership with an energy organization. Current annual tax payments per household, commercial consumer or industrial consumer are shown in the table below.

Customer category	CAP 2009	UOT 2020	CAP + UOT today	Proposed 2040
Household	USD 27	USD 16	USD 43	USD 38.20
Commerce	USD 86	USD 155	USD 241	USD 374.90
Industry	USD 128	USD 577	USD 705	USD 1389.89

Table 6: Average annual environmental tax payment per customer category

Source: City of Boulder, Colorado

From the above explanations on demand elasticity, the conclusion must be drawn that carbon taxes, if they are being introduced, this should not happen in form of a homogenous multi-sector large-scale uniform tax, but totally the opposite, a carbon tax should take as much as possible into account all relevant factors such as energy prices, availability of alternatives, substitution cost, location, sector or industry, or even household category, to name just a few factors. The tax rates should be highly specific and take all these situations into account. The reason for this is that taxes are administered prices and as such are not least cost options; see ETS below for the least cost alternative. Thus, a city in which electric mobility is already rolled out to a certain degree might have a higher carbon tax rate than a city in which this is not yet the case. The tax difference should, however, not be so large as to make fuel tourism worthwhile. Fuel tourism means going to a nearby low tax city just to refuel. Differentiation within a sector (e.g., between household categories) can only be implemented for grid-bound energies such as electricity or gas. For grid bound energies, high income households might have a higher carbon tax rate than low-income households.

A carbon tax raised at city level, as exemplified above, is also a means for avoiding hitting the population in the countryside having less technological choices. Cities are much denser in any respect than their surrounding countryside, placing city dwellers in a much better position to change technologies than their countryside neighbours. Taking motor vehicles as example, in the countryside there is a less dense infrastructure for EV charging as well as a less dense public transport infrastructure. Countryside dwellers face objectively more difficulties to change to EVs than city dwellers. The battery range of EVs may suit the higher density of cities but be insufficient for the lower density of countryside. A general carbon tax affecting both, cities and the countryside, may have the effect of an incentive tax in the cities where the possibilities of technical substitution are high, but be a fiscal tax in the countryside where the possibilities of technical substitution are lower. This is an argument in favour of city-specific carbon taxes.

2.2.3. Reallocation of Fossil Fuel Subsidies

Carbon taxes inevitably have a link to fossil fuel subsidies. The world still pays almost four times as much fossil fuels subsidies than subsidies to renewable power generation (2017). This figure only considers the direct subsidies. If also the indirect social cost of fossil fuels (pollution and climate cost) is considered, the fossil fuel subsidies are almost twenty times as high as the renewable power subsidies (see figure).

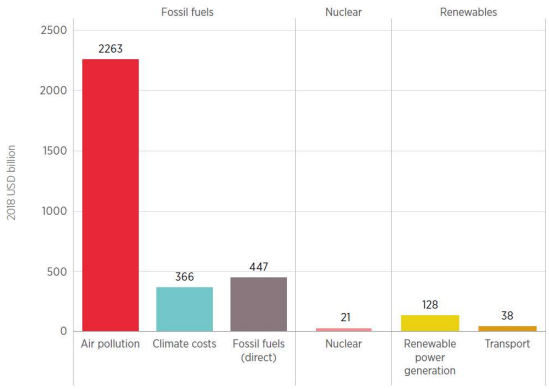


Figure 68: Global energy subsidies in 2017

Source: IRENA[155]

Fossil fuel subsidies are included in SDG 12.c which states: *Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities*. The corresponding indicator is 12.c.1, measuring the amount of fossil-fuel subsidies per unit of GDP (production and consumption) and as a proportion of total domestic expenditure on fossil fuels, showing such subsidies at global level amounting to about 0.5% of GDP in 2020, corresponding well with the direct fossil fuel subsidies of the preceding figure.

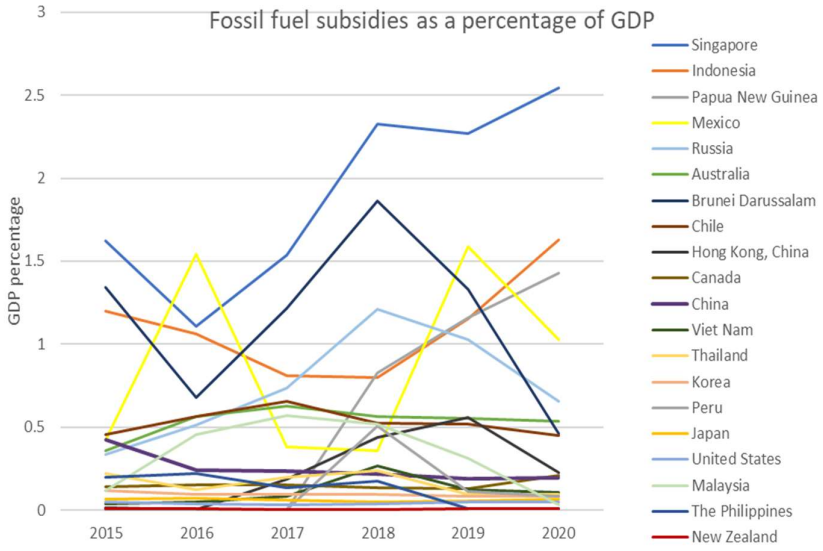


Figure 69: Fossil fuel subsidies (production and consumption-sided) of APEC economies

Source: Our World in Data[156]

APEC has started to address fossil fuel subsidies since 2009 (see further above section 2.2.3).

New Zealand together with some other parties has launched the Agreement on Climate Change, Trade and Sustainability (ACCTS) in 2019[157].

The study of fossil fuel subsidies is adversely impacted by the variety of subsidy forms in all three main categories (lowering fossil energy production cost, price subsidy for disfavoured fossil energy producers, and lowering the price for fossil energy consumers) and the multiplicity of definitions used by global organizations (WTO, IEA, OECD, World Bank, IMF all use different definitions). The IRENA has compared these and proposed a comprehensive energy subsidy strategy for 2050. Fossil fuel subsidies should be diminished by about one third, and half of the remaining fossil fuel subsidies should be directed to clean energy (EVs and energy efficiency) by 2050. Renewables support would remain more or less at present level. The IRENA analysis does not tell anything about a possible role of carbon taxes to contribute to financing this transition.

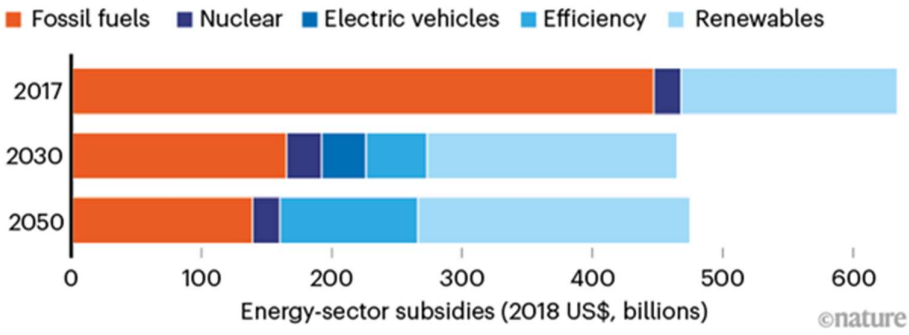


Figure 70: Scenario for global energy-sector subsidies till 2050

Source: IRENA, quoted in Nature[158]

For green finance, this IRENA scenario is insofar important as it considers about $300 billion of the present fossil fuel subsidies as additional source for green finance every year.

Due to their broad scope, covering both, support to fossil energy producers as well as support to fossil energy consumers, fossil fuel subsidies are hard to eliminate. When energy prices are low, consumer subsidies can easily be eliminated, but fossil energy producers with production costs above market prices are likely to call for support. When energy prices are high, the situation is inverted, meaning that support to fossil energy producers can easily be eliminated whereas fossil energy consumers (especially vulnerable groups) are then likely to call for protection by means of subsidies.

A genuine problem with price-related subsidies is that they provide benefits not only to the poor and needy, but to anybody who buys the price-subsidized product on the respective market. This means that beggars and billionaires are being subsidized alike. As this is not considered efficient and is often not wanted, price-related subsidies are replaced by income-related subsidies which are more efficient and targeted. The prerequisite for the subsidy granting administration is to know the income of all those who are supposed to benefit from the subsidy.

To manage a successful transformation as outlined by IRENA, authorities can act as follows:

- When energy prices are low, it is easy to remove price-related consumer subsidies, redirecting these to clean energy (renewables, EVs, energy efficiency) instead. In these times it is important to refrain from introducing price-related support for fossil energy producers whose production cost is above market prices (i.e., authorities should let them fail).
- When energy prices are high, it is easy to remove price-related producer subsidies. In these times it is important to refrain from re-introducing price-related support to vulnerable fossil energy consumers. Instead, income-related support to these groups can be extended and possibly combined with specific measures incentivizing the transition to clean energy.
- Modest, well differentiated carbon taxes raised at local level, should help generating green finance as a contribution to clean energy transition.

2.2.4. Emission Trading Systems ETS (Black Certificates)

Emissions Trading Schemes (ETS) are the most cited alternative to carbon taxes for setting a carbon price. ETS are an invention of the 1960s. The basic idea of an ETS is that it is possible to trade a "bad" (e.g., an external cost) in the same way as one can trade a "good". This innovation bases on a theoretical description made in 1960 by the economist R. H. Coase[159] who was awarded the Nobel Prize of economics in 1991 for this discovery. Basically, the important elements allowing this to happen are sufficiently clear property rights stating who owns the "bad", and sufficiently low transaction costs. Most ETS systems are cap-and-trade systems, requiring the authority to set a pollution (e.g., CO_2 emissions) cap and allowing trading for possible pollution surplus or deficits. The great advantage of ETS systems is to be the least cost option for mitigating pollution; an ETS will normally lead to mitigating the pollution first in those areas where the abatement cost per mitigated ton of pollutant is least. For this result to materialize, it is important that as many as possible economies introduce an ETS and that as many ETS as possible are linked among each other, allowing in particular for transfer of certificates from low abatement cost areas and sectors to high abatement cost areas and sectors.

Today ETS systems and carbon taxes are often listed side by side. The World Bank keeps the global overview of existing ETS and carbon taxes. The below up-to-date map does not mention some of the carbon tax or ETS systems that have existed in the past (e.g., Australia, Rio de Janeiro, Sao Paolo) but were then abandoned.

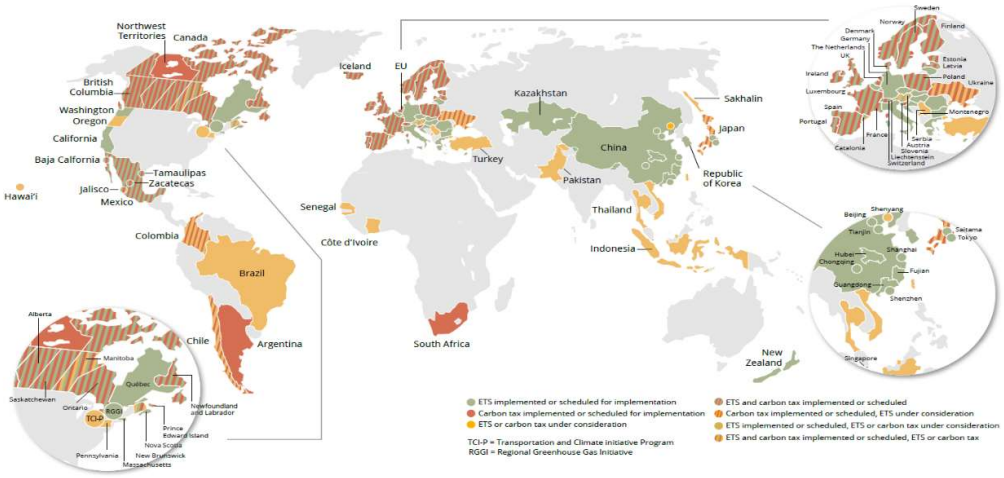


Figure 71: Carbon pricing map (2021)

Source: World Bank[160]

The question as to how much and what type of green finance is raised by an ETS merits attention. ETS is a least cost option for mitigating a pollution, which means that it minimizes cost of eliminating pollution. With carbon tax it has in common to put a price on pollution. According to the definition given section 2.1.1, such funds can be called green finance if they are invested in green projects. ETS raises funds from those high-cost abatement industries or locations where abatement cost is higher than the market price of CO_2. An ETS failing to specify that the destination of the funds are green activities is not necessarily creating green finance. The clarifications made by COP26 (see further down) show that henceforth also green projects are part of the system, removing doubts about the green finance character of ETS systems that comply with the new rules.

ETS are major technological innovations that have been tested in computer simulations in the US since 1967 and steadily improved ever since[161]. The first large-scale application of an ETS was the acid rain program in the US run in the 1990s. The program called for cutting sulphur dioxide (SO_2) emissions from US power stations by half within two decades. The program allocated an ever-decreasing amount of free emission rights to the power sector and required it to deal with cutting the remaining emissions. By 2010, the emissions were down by more than two thirds, over-fulfilling the target of the program.

ETS for greenhouse gases received a strong push in the 1997 Kyoto Protocol which was the first international agreement with legally binding reductions and limits of greenhouse gases. The Kyoto Protocol provided for three ways to trade carbon reductions, so-called flexibility mechanisms: International Emissions Trading (IET) as trading mechanism, the Clean Development Mechanism (CDM) and the Joint Implementation (JI) as project-based offsetting mechanisms. Despite the difficulties of the Kyoto Protocol due to the absence of the US and, later, Canada, the three flexibility mechanisms have measurably diminished global emissions[162][163]. To the extent this happened, they have contributed to the creation of green finance.

The history of the European ETS for greenhouse gases started in 2005. In 2005, a group of 24 global enterprises participating in a WEF meeting associated with the G8 called upon the G8 to deliver market-based solutions to address climate change[164]. The same year, the EU launched its ETS which has been the leading global ETS in the past years.

As mentioned earlier, the price signal of an ETS is comparatively more volatile compared with the price signal of a carbon tax, which will usually vary only with the price of the underlying fossil fuel. The volatility of an ETS can be seen in the figure below. The ETS price will notably depend on the number of free certificates allocated to the market, on whether the authorities sell supplementary certificates beyond the free allocations, on the demand-supply balance and the mean ratio between internal mitigation and external offsetting decided by the market actors, as well as on any other event such as financial or other crises influencing the global business climate, or important climate policy decisions taken by authorities.

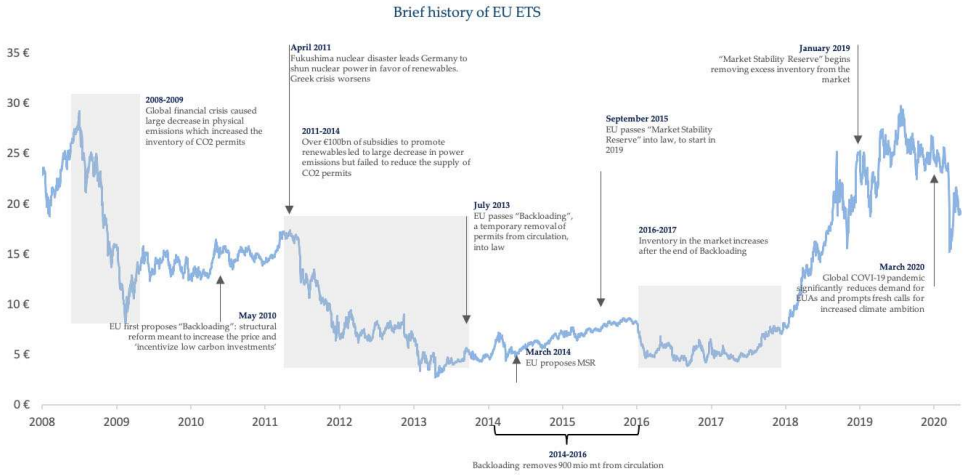


Figure 72: A brief history of the EU-ETS

Source: Hatree Solutions[165]

Judging from the above figure and knowing that a carbon price is effective as soon as it is above 20 EUR, the ETS has not yet started having significant effects. One of the reasons of

the low carbon price between 2009 and 2018 has been the oversupply of allowances. This oversupply was at least partially wanted because the ETS should not produce carbon leakage. In the framework of the European Green Deal presented in December 2019 and its “Fit for 55” package presented in July 2021, the EU is discussing the Carbon Border Adjustment Mechanism (CBAM) as a complement to a revised and more efficient ETS. It is mainly designed to incentivise the EU’s trading partners to link their ETS with the EU ETS to work towards a global ETS. The ETS is not a tax-based system and hence the CBAM can in principle be constructed to be WTO compatible.

Figure 73: Blueprint of the EU Carbon Border Adjustment Mechanism

Source: European Commission[166]

On 16 July 2021, China started its own ETS system. The Chinese ETS is not a pure a cap-and-trade scheme in which the carbon allowance supply is gradually being reduced to ensure emission reductions. Instead, China created a ‘flexible cap’ whereby allocations are made according to an intensity formula that considers total power generation, power generator’s size, and fuel type, among others, to calculate carbon allowances. The first plans to open an ETS in China were announced back in 2011. In the years 2013 – 2014, seven pilot projects were first launched at provincial level (Beijing, Tianjin, Shanghai, Guangdong, Shenzhen, Hubei, and Chongqing)[167].

The opening price of the Chinese ETS was set at 48 yuan per tCO_2, rising to 52.8 yuan/tCO2 by the end of the day. During the first two weeks after the launch of the domestic ETS, about 6 million tons of CO_2 allowances have been traded for a value of about 300 million yuan. As of 5 August 2021, prices fluctuated between 53 yuan and 59yuan/ton.

In the initial phase the domestic ETS applies only to some 2162 electric power plants covering some 40% of Chinese CO_2 emissions or 15% of global CO_2 emissions. It will make renewable electricity more competitive and hence favour renewable electricity investments. The system defines four benchmark categories: conventional coal plants below 300 megawatts (MW), conventional coal plants above 300 MW, unconventional coal, and natural gas. Besides electricity (including power generation and power and heat cogeneration), other sectors are scheduled to be included in future: buildings, iron and steel, non-ferrous metal processing, petroleum refining, chemicals, pulp and paper, and aviation.

The question remains what will happen with the provincial trading systems once the domestic ETS is fully implemented. As their scopes are quite different from each other, they might continue to co-exist with the economy-wide system, provided they do not overlap with

the latter. For that, they need either to shift to other sectors or towards including below-threshold polluters.

Figure 74: Opening day of the Chinese ETS in Wuhan 16 July 2021

Source: China Dialogue[168]

ETS systems worldwide are likely to receive a new impetus following the decisions taken at the COP 26 held in Glasgow in November 2021. This conference finally managed to reach consensus on the long-awaited global rules facilitating cooperative approaches on compliance markets to achieve climate targets (Articles 6.2, 6.4., and 6.8. of the Paris Climate Agreement). Compliance markets are mandatory compliance rules set up by authorities, contrary to voluntary markets which might be set up by any other organization and linked to compliance markets subject to specific arrangements. An example of a voluntary market is Carbon Offsetting and Reduction Scheme for International Aviation ("CORSIA")[169].

The Glasgow Climate Pact refers to the 1.5°C target as necessary rather than aspirational, incentivising actors to raise their climate ambitions and submitting revised climate targets within one year, i.e., three years earlier than originally planned. It contains strong language on diminishing the global emissions by 45% by 2030 compared to 2010, phasing-down coal power and phasing out inefficient fossil fuel subsidies.

Article 6.2. on Internationally Transferred Mitigations Outcomes (ITMO) is building on the Kyoto Protocol's IET mechanism which it replaces to become the new basic instrument for emissions trading. The ITMO accounting rules provide for using the certificate only once and avoiding double counting reductions in the host and donor locations. They also allow choosing as accounting units either CO_2eq emissions, or renewable energy with corresponding conversion factors (see section 2.2.5 on green certificates). With the measurement, reporting and verifying (MRV) framework, the ITMO has the potential to become a new "gold standard" for emissions trading, even though experience will have to demonstrate its success. ITMO trading requires cooperation between governments and private actors (see figure).

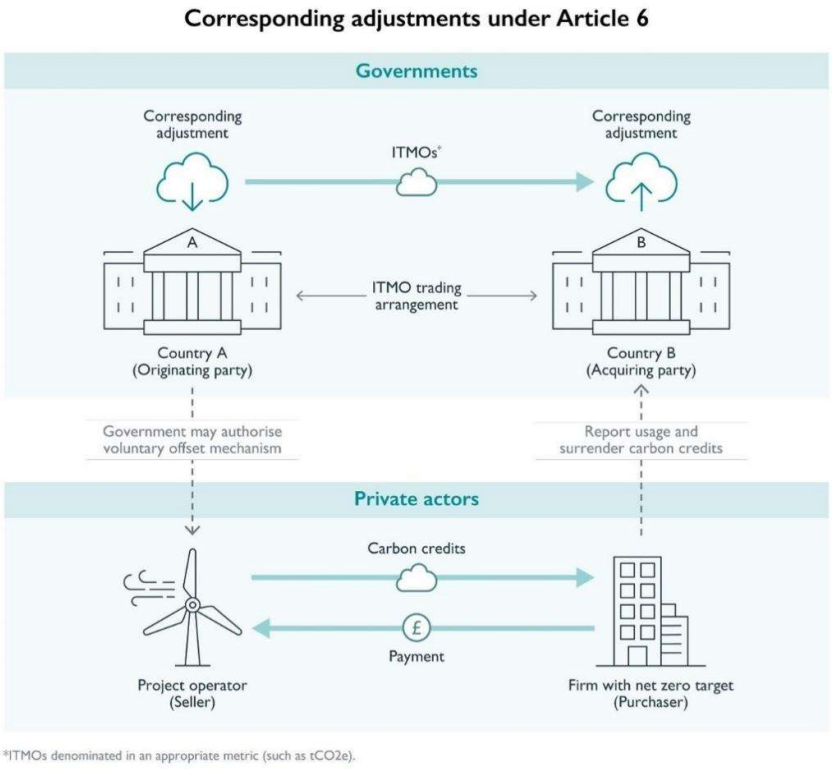


Figure 75: Example of an ITMO transfer and corresponding adjustment

Source: Slaughter and May (2021)[170]

Article 6.4. as clarified by the Glasgow Climate Pact defines the Sustainable Development Mechanism (SDM), the successor of the earlier Kyoto Protocol's project-based offsetting mechanisms (CDM and JI). The SDM is expected to create an appreciable proportion of green finance based on eligible projects, especially when these are admitted into the compliance markets. To be eligible, projects must have additionality, i.e., they must provide the proof that they would not have been made without investment from the SDM, considering existing and anticipated laws of the host jurisdiction. Determining the baseline emissions trajectory against which emissions reductions are measured must apply one of the following methodologies:

- The best available technologies which are economically feasible and environmentally appropriate for each activity.
- The average emissions level of the best-performing comparable activities that provide similar outputs and services in equivalent social, economic, environmental, and technological circumstances.
- Actual or historical emissions, adjusted to align with the host economy's NDCs and low-emissions development strategies.

The SDM allows financing projects for emissions avoidance (e.g., avoiding a coal-fired plant by installing a renewable energy plant) and a project duration between 5 and 15 years, as well as projects for emissions removal (CCUS or direct emissions capture), with a project duration between 15 and 45 years. A Supervisory Body must formally register all the projects after validation by an independent accredited auditor called Designated Operational Entity DOE that verifies and certifies emissions reductions. The SDM activity cycle is shown in the figure below.

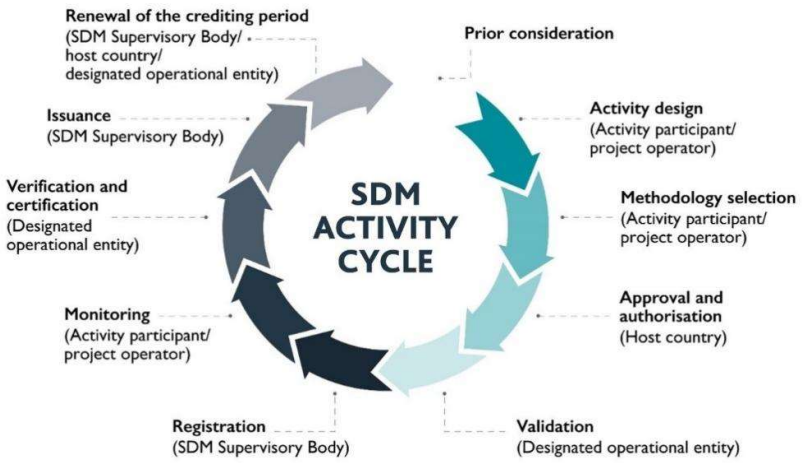


Figure 76: The SDM activity cycle

Source: Slaughter and May (2021)[171]

As a particularity of the SDM, 5% of the emissions credits must be paid into a United Nations Adaptation Fund, allowing to pay for climate resilience in developing economies. As a transitional arrangement, the SDM allows carrying over unused carbon credits from the former CDM from projects registered since 2013, which could amount to a sum of 173 million USD.

Article 6.8. of the Paris Climate Agreement clarified at the Glasgow COP 26 addresses the so-called non-market approaches or non-market initiatives. The most important of these is the announcement made at COP 26 by the Glasgow Financial Alliance for Net Zero (GFANZ), a global coalition of 450 leading firms and financial institutions in the UN's Race to Zero, to deliver an estimated $100 trillion of finance needed for net zero over the next three decades. Members of the GFANZ are the

- The Net Zero Banking Alliance,
- the Net Zero Asset Managers initiative,
- the Net Zero Asset Owner Alliance,
- the Paris Aligned Investment Initiative,
- the Net Zero Insurance Alliance,
- the Net Zero Financial Service Providers Alliance,
- and the Net Zero Investment Consultants Initiative.

With the commitment of the GFANZ, the required scale and direction of green finance reaches a scale that can bring about the transition to Net Zero.

This section should not finish without briefly outlining the role of voluntary carbon markets which could be a way for cities to engage themselves and their citizens towards net zero. Voluntary markets are project-based markets. COP26 in Glasgow has incentivized setting higher climate ambitions worldwide, which drives the price on voluntary markets upward. Voluntary markets responded by creating a Taskforce for Scaling Voluntary Carbon Markets TSVCM[172]. This task force should elaborate a set of Core Carbon Principles allowing voluntary carbon markets to become high integrity markets that can cooperate with compliance markets. Without stringent rules, the Voluntary Carbon Markets might become the most important means to greenwash economic activities. Without clear information on buyers of such certificates and owners of the projects they finance, it cannot be controlled whether these markets promote the green economy.

Meanwhile some cities are setting up voluntary carbon markets. Often cities focus on increasing forest cover by means of voluntary carbon markets. Asia is the place where such markets have highest growth.

	2019		2020		2021 (through August)	
	Volume (MtCO2e)	Price (USD)	Volume (MtCO2e)	Price (USD)	Volume (MtCO2e)	Price (USD)
Africa	16.1	$3.94	14.9	$4.24	23.9	$5.52
Asia	45.6	$1.80	63.0	$1.60	91.8	$3.34
Europe	1.1	$2.92	1.7	$9.47	0.8	$2.96
Latin America & Caribbean	15.3	$3.45	18.9	$4.17	36.6	$3.74
North America	15.5	$3.51	11.6	$6.31	10.0	$5.13
Oceania	0.5	$12.53	0.1	$20.57	0.1	$32.93

Figure 77: Voluntary City-level Carbon Markets Worldwide

Source: Forest Trends Association's Ecosystem Marketplace, 2021[173]

While it may in principle be a sound idea to finance the maintenance forests with voluntary carbon markets, it should not be forgotten that this may require monitoring a certain number of key indicators in the forests themselves. Indeed, measuring such indicators in forests could be the main activity of any forest project. The business model of a sustainable forest might need to contain elements of sustainable tourism to make it become economically viable.

2.2.5. Energy Attribute (or Green) Certificates

Energy attribute (or green) certificates are financial certificates that certify and compensate the greenness of a produced energy form. Mostly this applies to green electricity as greenness is conveniently defined as renewable and electricity is the most relevant energy form for this purpose. A producer of renewable electricity can request a recognized certifying organization to certify that a given MWh of produced electricity satisfies the set criteria, which allows him to issue the certificate. Such certificates can then be sold to consumers having either portfolio standards (compliance markets, or the obligation to buy a certain percentage of their portfolio from renewable energy suppliers), or the intention to show to the public at large that they support the green economy by supplying themselves from renewables (voluntary markets). From their design, green certificates can be traded independently from the physical electricity flow.

The advantage of green certificates is to provide a cost-minimizing option to achieve a green electricity portfolio, or to increase the share of renewable electricity. This function is the equivalent of the black certificates which provide for a cost-minimizing option to achieve emissions reductions. Green certificates operate by the same mechanism, namely by increasing the share of renewables first in those places and by those technologies that are the most cost-effective. Like the black certificate markets, the green certificate markets operate best if the greatest number of local markets are linked among each other.

Green certificates have different names depending on the region where they are being issued. In the US and Canada, they are called Renewable Energy Certificates (RECs), in

Europe they are called Guarantees of Origin (GO), and in major parts of Latin America, Africa and Asia they are called International RECs (I-RECs) and Tradable Instruments for Global Renewables (TIGRs). In Australia, Japan and Korea, domestic systems prevail. The I-REC standard established in 2014 in the Netherlands operates a single global registry through which energy products from renewable sources can be certified through the electricity supply chain.

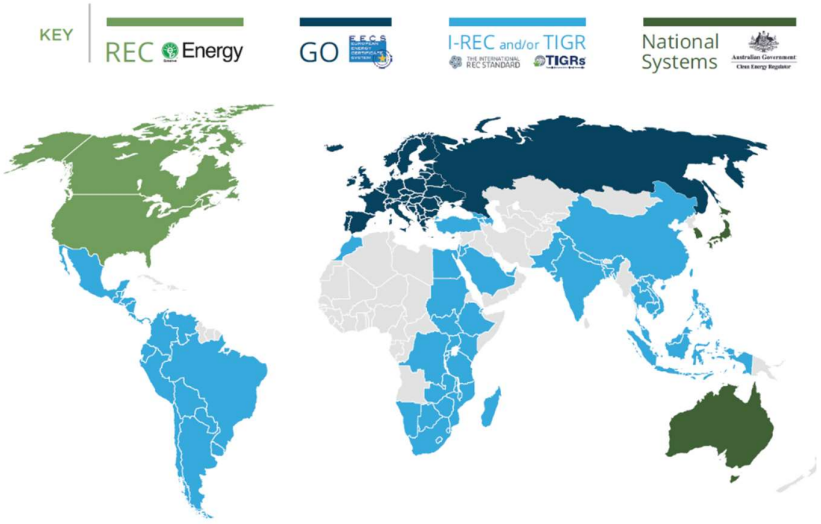


Figure 78: Geographical areas of REC, GO, I-REC/TIGR and domestic systems

Source: Natural Capital Partners[174]

As they are traded independently from the electricity itself, green certificates are genuine financial instruments having the effect to raise green finance and channel it to producers of certified green energy. Certificates state the date, producer and technology used to produce the electricity in question. The necessary design characteristics of the trading system are that any one MWh slice of renewable electricity may only allow issue of one single certificate, and that any issued certificate must be cancelled after having been counted towards the fulfilment of any obligations or labelling declarations.

Green certificates certify the production of renewable electricity, but do not certify the addition of renewable capacity. To satisfy this latter purpose, the certificate would have to be designed in another way.

How do these green certificates compare to the emissions trading certificates (called black certificates to distinguish them from the green ones)? Their achievements are quite different and are also measured in different measurement units. The green certificates measure renewable energy expressed in MWh and allow the consumers to direct additional green finance towards green electricity producers, whereas the black certificates measure CO_2eq reductions measured in tCO_2eq and allow CO_2 emitters who overfulfill emissions reductions to sell these to emitters who are not fulfilling the reduction obligation and pay instead for the certificates. In principle the two markets are totally distinct.

The question arises whether emitters who are not fulfilling the reduction obligations should be allowed to buy green certificates instead of black ones. The agreement reached at COP 26 (see section 1.3.1 above) allows in principle to do this (so-called use of CO_2eq or green energy as accounting units). One of the possibilities is that a CO_2 emitting power producer invests in green electricity to increase his share of renewables. This is likely to happen more and more often during the energy transition. As the international transfer of the certificates is now allowed,

the two markets become interlinked. Therefore, a producer can choose whether to certify and sell either his CO_2eq reduction or his renewables (but not both at the same time).

The agreement reached at COP 26, while allowing for the use of both types of certificates, also has limited the possibilities of using green certificates in power pools reaching over several economies to transfer reduction allowances between the participating economies. In APEC, power pools involving several economies only exist in US-Canada and in the Mekong basin.

As a matter of principle, SDGs are voluntary goals and targets, and their fulfilment is also voluntary. As COP26 has now created a compliance market for emissions reduction and linked green electricity to it, and as several SDG indicators directly or indirectly monitor one of these two (13.2.2 Total greenhouse gas emissions per year, 9.4.1 CO_2 emission per unit of value added, 7.2.1 Renewable energy share in the total final energy consumption), the compliance markets should henceforth be counted towards the fulfilment of these SDGs.

By the way, the Paris Climate Agreement and its derived texts excludes that all, or even a major part of, carbon reductions of compliance markets are achieved by trading; trading can only be a supplement to domestic measures. As a result, the part added by compliance markets is not expected to be large, at least not immediately. It would, however, not be a surprise if the contribution of markets was growing in future years as abatement costs become unbearably high in certain places.

The question as to what opportunities and challenges green certificates can bring to cities is worth to be addressed. For cities, green and black certificates offer the possibility to drive decarbonization and the increase of urban renewables. It is much easier to set ambitious local emissions targets or renewable portfolio standards if the flexibility to allow satisfying a part of them by certificates is granted.

Cities can receive targets from their central government, in which case they might be invited to participate in compliance markets allowing them to minimize cost. Such targets can be either CO_2 reduction or renewables' increase targets. Targets can be split down to electricity producers, industries, the transport sector or buildings, depending on the case. Participation in the compliance market would then be the way to make the target attainment cost-effective.

Cities can also engage in voluntary markets and attempt to link them to compliance markets by fulfilling the required criteria. With the inclusion of green certificate voluntary markets, the scope of application of city-scale voluntary markets can be increased. It is now possible that a city includes virtually all its urban renewable electricity into a voluntary market. Furthermore, the green electricity produced outside the city and consumed in the city can be certified with green certificates. Depending on the host economy and other conditions, such voluntary market may or may not be linked to the compliance market. Voluntary markets have also a merit on their own, justifying setting them up even if linking them to compliance markets is not possible.

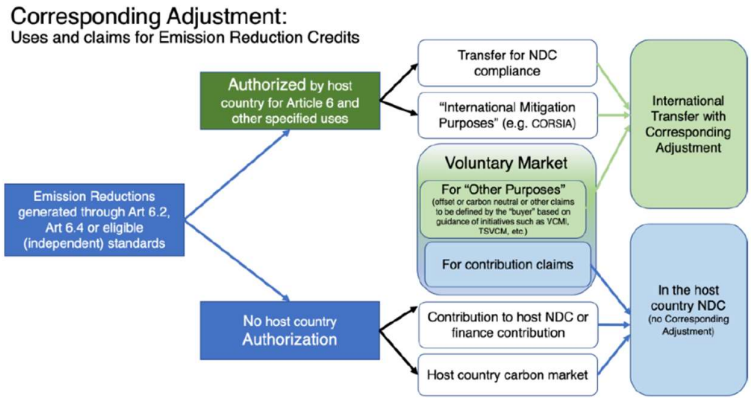


Figure 79: Linking compliance and voluntary markets

Source: ERCST[175]

Cities can also drive the energy transition and the process of increasing the share of renewable urban energy by buying green certificates on voluntary markets covering the municipal administration's own energy consumption.

2.2.6. Feed-in Tariffs (FIT)

Feed-in tariffs (FIT) have been pioneered in Germany in the 1990s and subsequently used in many other parts of the world as an instrument to favour the creation of renewable energy of all sizes and types. In fact, among the different incentivizing instruments presented in this report, feed-in tariffs are the most effective one in the sense of producing the most rapid increase of the production capacity of renewable energy. For this reason, they are also a powerful tool to raise green finance.

Essential elements of FITs are:

- A long-term (typically 15 – 20) years agreement between a renewable energy producer and a utility to supply renewable electricity using a specified technology
- A guaranteed fix price or a degressive price reflecting the expected effect of technological progress and learning curve on cost
- The price being strongly different for each technology
- The cost of the system being borne by all electricity consumers connected to the grid
- Some type of quotas for each technology and each year to avoid explosive deployment of the technology

The main problem of FITs is their success. Without the quotas mentioned in the last bullet point, deployment of renewable electricity would be so rapid that electricity system operators might not be able manage the consequences, namely the intermittent nature of renewables, on system stability.

A further problem is that up to now, most FITs do not cover storage, justifying once more the necessity to set the above-mentioned quotas.

A third problem is that the prices set in advance and applicable over a long-term period may be different from the prices set by the market. This might increase the average electricity price and diminish competitiveness of the economy.

A fourth problem is that FITs are not compatible with other instruments such as certificates described in earlier sections. That means that a producer to whom a FIT has been granted, will (or should) not be able to participate in certificate trade. FITs and certificates may exist along each other in the same economy, but not applied to the same producer. As certificates are the most cost-effective way to bring about the energy transition and the world has basically chosen certificates (whose development is at present still far below its potential), FITs have a role as initial, technology-specific instruments which might now shift towards cities and the local level. Local FITs might be an instrument of choice for setting up renewable energy with or without storage in or near cities or municipalities having the need to catch up, i.e., having installed capacity below 1900W/capita, the energy needed to power Decent Living Standards entirely with renewable energy (see section 1.1.4). Storage could in the first place consist of reusing batteries of electric vehicles having reached the 60% capacity threshold below which they must be changed. At grid-scale, flow-batteries are appropriate (see section 2.1.3).

The remaining part of this section will be used to describe cases of FIT introduced at local level.

In February 2009, the city of Gainesville, Florida, introduced a local FIT whereby the Gainesville Regional Utility granted a 20-year contract to buying surplus PV electricity at a fix price. The exact price depended on the current cost of solar PV panels and the size of the installation. Gainesville had set an expansion cap to 4MW per year.

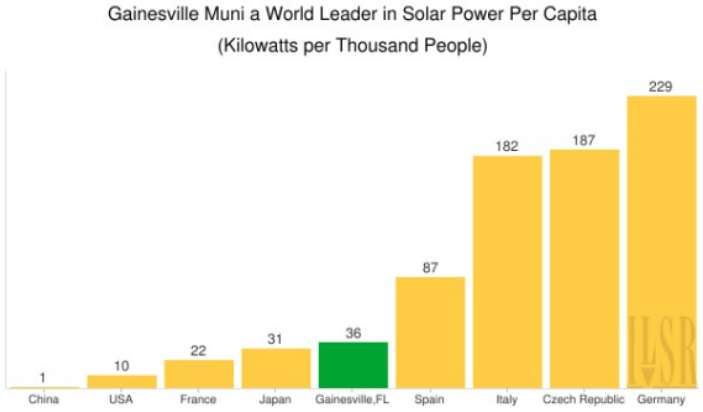


Figure 80: Installed renewable capacity in Gainesville, Florida

Source: FastCompany[176]

By 2011, the city was in the headlines as this program had allowed to install 7MW of solar power for roughly 200,000 people, corresponding to 35W/capita, making the installed capacity per capita become more than triple the United States average. The program has been stopped since then. Gainesville homeowners can still benefit from other financial incentives like tax credits, tax exemptions, and net metering programs.

Another case of a local FIT is reported from Anaheim, California. Since 2003, this city has started planning its energy mix, driven by California's renewable portfolio standard. This state-level standard requires all Californian utilities to successively increase the amount of renewable energy delivered to customers. According to the latest (2018) plan, California should have 60% renewables by 2030 and be carbon neutral by 2045.

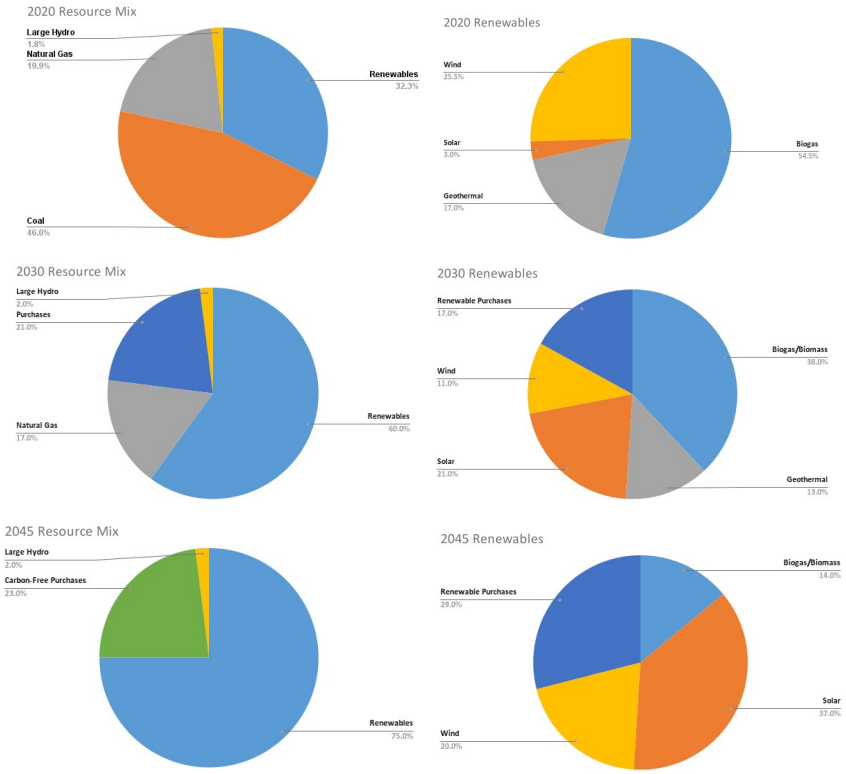


Figure 81: Renewable portfolio standard of California, 2020, 2030, and 2045

Source: Anaheim municipality[177]

Anaheim uses a FIT as instrument of choice allowing its citizens to attain the target. The type of supported installation must be between 100kW and 3000kW[178]. Owners are free to choose contract terms of 10, 15, or 20 years. From 2004 to 2020, Anaheim Public Utilities has increased renewable energy from 1% to 32% while reducing coal power from 73% to 46%.

The California state law requires utilities to disclose the electricity mix in a power content label. The label of Anaheim Public Utility is shown below.

A Guide to Anaheim's Power Content Label

Column A (Energy Resources)

This column lists the different energy resources that can be used to generate electricity, including eligible renewable resources and other resources.

Column B (Power Mix)

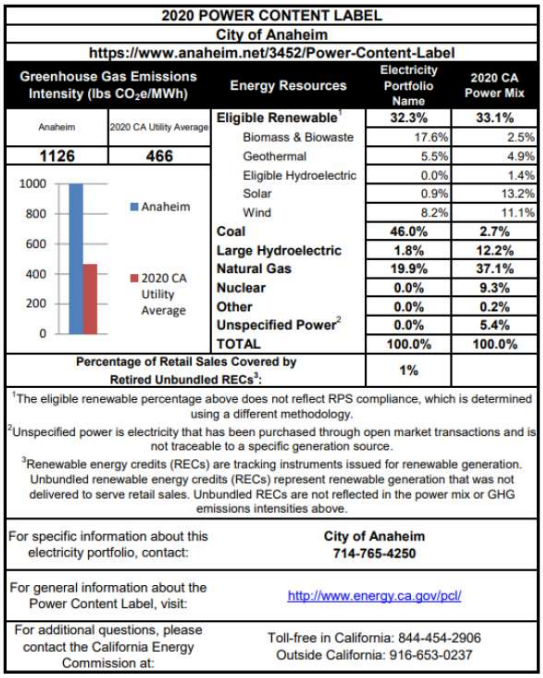
This column displays the actual mix of electricity purchased by Anaheim per product offering in a given year, broken out by resource type.

Column C (Green Power Mix)

This column displays the actual mix of electricity purchased by Anaheim per product offering in a given year, broken out by resource type, to meet the energy needs of residents who voluntarily selected to participate in the Green Power Program.

Column D (California Power Mix)

This column displays the mix of resources used in California for a given year. This information is provided as a reference point for you to compare Anaheim's resource mix to the overall resource mix of the state.



2020 POWER CONTENT LABEL
City of Anaheim
https://www.anaheim.net/3452/Power-Content-Label

Greenhouse Gas Emissions Intensity (lbs CO_2e/MWh)		Energy Resources	Electricity Portfolio Name	2020 CA Power Mix
Anaheim	2020 CA Utility Average			
1126	466	**Eligible Renewable**[1]	**32.3%**	**33.1%**
		Biomass & Biowaste	17.6%	2.5%
		Geothermal	5.5%	4.9%
		Eligible Hydroelectric	0.0%	1.4%
		Solar	0.9%	13.2%
		Wind	8.2%	11.1%
		Coal	**46.0%**	**2.7%**
		Large Hydroelectric	**1.8%**	**12.2%**
		Natural Gas	**19.9%**	**37.1%**
		Nuclear	**0.0%**	**9.3%**
		Other	**0.0%**	**0.2%**
		Unspecified Power[2]	**0.0%**	**5.4%**
		TOTAL	**100.0%**	**100.0%**
		Percentage of Retail Sales Covered by Retired Unbundled RECs[3]**:**	**1%**	

[1]The eligible renewable percentage above does not reflect RPS compliance, which is determined using a different methodology.
[2]Unspecified power is electricity that has been purchased through open market transactions and is not traceable to a specific generation source.
[3]Renewable energy credits (RECs) are tracking instruments issued for renewable generation. Unbundled renewable energy credits (RECs) represent renewable generation that was not delivered to serve retail sales. Unbundled RECs are not reflected in the power mix or GHG emissions intensities above.

For specific information about this electricity portfolio, contact:	**City of Anaheim 714-765-4250**
For general information about the Power Content Label, visit:	http://www.energy.ca.gov/pcl/
For additional questions, please contact the California Energy Commission at:	Toll-free in California: 844-454-2906 Outside California: 916-653-0237

Figure 82: Anaheim's Power Content Label

Source: Anaheim municipality[179]

Several examples of cities having introduced a local FIT can be found in South Africa.

NAME	SEAT	TYPE	NOTES
City of Johannesburg Metropolitan Municipality	Johannesburg	Feed-In-Tariff	**Embedded Generation ≤1 MW**Residential: R0.4279/kWh Commercial: R0.3614/kWh
City of Cape Town Metropolitan Municipality	Cape Town	Feed-In-Tariff	**Small-scale Embedded Generation ≤1 MW**Residential: R0.7008/kWh Commercial: R0.7008/kWh
eThekwini Metropolitan Municipality	Durban	Feed-In-Tariff	**Residential Embedded Generation**Single Phase: ≤2.6 kW Three Phase: ≤13.8 kW Residential: R0.68/kWh
Ekurhuleni Metropolitan Municipality	Germiston	n/a	• Currently no incentive program • Grid-parallel photovoltaic solar systems are allowed
City of Tshwane Metropolitan Municipality	Pretoria	n/a	• Currently no incentive program • Grid-parallel photovoltaic solar systems are allowed
Nelson Mandela Bay Metropolitan Municipality	Port Elizabeth	Net Metering	**Small-scale Embedded Generation ≤1 MW**Residential: 100% of electricity cost

			Minimum cost: R0.00 Up to 1 year credit when monthly generation exceeds consumption
Buffalo City Metropolitan Municipality	East London	n/a	• Currently no incentive program • Grid-parallel photovoltaic solar systems are allowed
Mangaung Metropolitan Municipality	Bloemfontein	n/a	• Currently no incentive program • Grid-parallel photovoltaic solar systems are allowed

Figure 83: South African municipalities having introduced FIT or Net Metering

Source: Solar Energy Life[180]

These example are listed here for information showing that the use of FITs is not limited to developed economies.

2.2.7. Power Purchase Agreements (PPA)

Power purchase agreements (PPAs) are the generalized form of agreements underlying feed-in tariffs (FITs) which have been described in the preceding section. While the specific type of agreement granting FITs is usually applied to small PV producers, the more generalized form of PPAs have been used for decades in the mainstream power industry to all sizes of producers. More recently, PPAs have been used specifically to drive the expansion of renewable energy. When used in this purpose, they are sometimes combined with renewable energy certificates (RECs) as measure of support (see section 2.2.5 on RECs).

PPAs are usually characterized by one party (the customer or off-taker) being a non-profit public entity (e.g., a municipality) and the other party (the seller or electricity producer) being a commercial electricity producer. As they combine a public and a private party, PPAs are a form of PPPs (public private partnerships). PPAs are often combined with a BOT scheme or a concession (see section 2.2.8 on PPP).

PPAs are the instrument of choice of municipalities wanting to increase the share of renewable energy. However, not all PPAs are equally successful in promoting renewable energy. If minimum price is kept as one of the important criteria, it is necessary to attribute PPAs in internationally competitive tendering. Indeed, the immense price drop, expressed as levelized cost of energy LCOE (which is the minimum electricity cost that makes the project viable over its lifetime), experienced by solar and wind energy during the last decade can be attributed to international competitive tendering for PPAs (see figure below). PPAs specify at least three elements: price, quantity to be delivered, and duration.

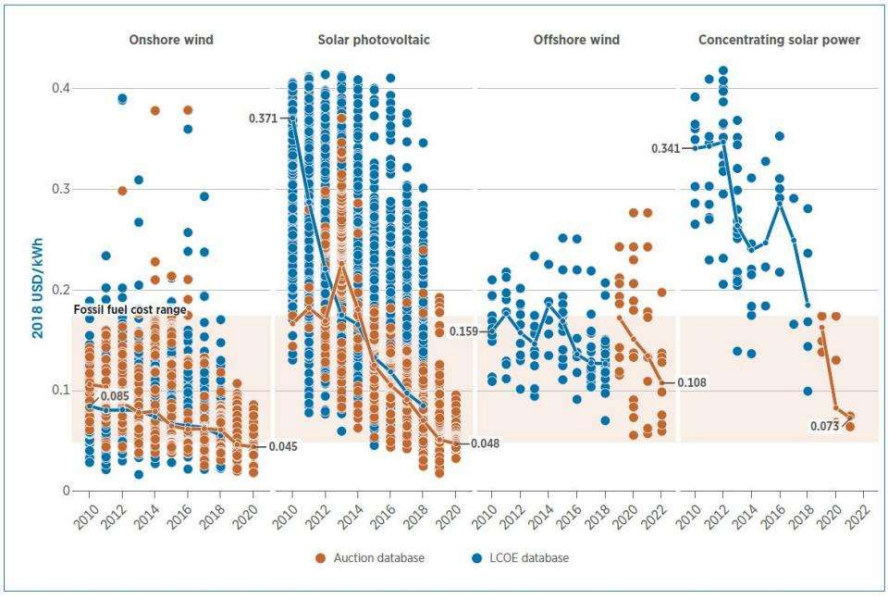


Figure 84: Cost of the four key renewable technologies, 2010 – 2022

Source: IRENA[181]

The PPAs concluded specifically to increase the quantity of renewable energy happen normally as addition to the existing contracts and flows which comprise all forms of energy, including fossil and nuclear. The following scheme, made from the point of view of a customer (a city) illustrates the existing flows (grey) and the additional flows (yellow) which are occurring in a power grid after conclusion of a PPA (red) for renewable energy compensated with RECs (blue) and the corresponding payment for both, electricity and the certificate (green).

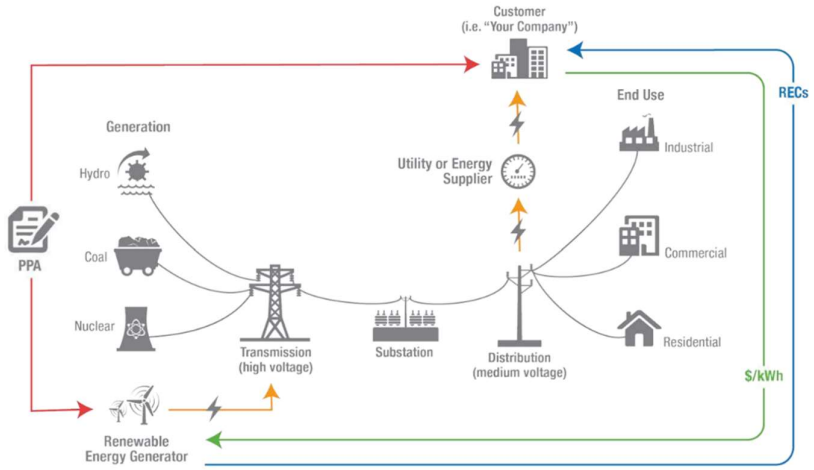


Figure 85: Flows in a physical PPA

Source: EPA[182]

The above scheme is valid for a physical PPA. Physical PPAs can only be concluded if the market from which the customer receives the electricity supply is the same as the market in which the renewable energy generator supplies the energy. Physical PPAs are the contract form which is adapted to integrated, not unbundled and not liberalized electricity markets.

In liberalized electricity markets the customer negotiates with individual suppliers but receives the agreed electricity supply from the distribution system operator to whom he is connected. The market operator (a kind of clearing centre) must ensure that at least the sum of the energy bought by all customers at any moment of time is being supplied by the producers who have announced their production for the period in question. Physical flows will not take place directly between the producer and the customer. For liberalized and unbundled electricity markets, the appropriate contract form is the virtual PPA (vPPA).

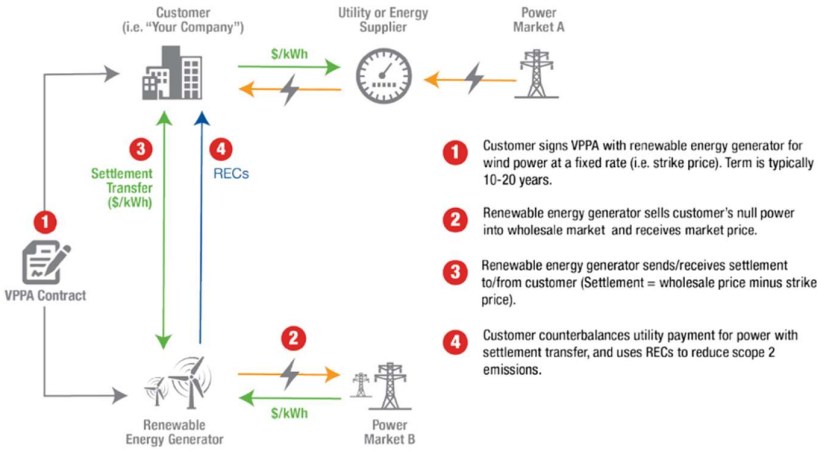


Figure 86: Flows in a virtual PPA

Source: EPA[183]

After signing the vPPA (1), the renewable energy generator produces into power market B (2) whereas the customer is supplied from power market A. The payment and settlement of differences is made directly between the customer and the electricity generator (3) who also emits the RECs (4). Settlements (green) can go in both directions as the vPPAs usually incorporate a provision referring to future market price. During periods when the convened (or "strike") price is different from the local retail price, a corrective payment can take place in either direction. Not shown on the diagram is the clearing between power markets A and B which is necessary but totally independent from vPPA.

VPPAs incentivise renewable electricity production but they do so in the market where the producer is located. Depending on electricity regulations and local renewables production potentials, this can be far from the city. Cities that have never concluded PPAs nor vPPAs may need to prepare themselves by checking the following points[184]:

• Conduct electricity audit and assessment on current usage and implement any energy efficiency measures to reduce demand

• Establish baseline needs after energy efficiency measures are implemented, incorporating future demand projections

• Set energy goals for community/municipality and engage stakeholders early

• Assess which type of PPA is most suitable given city's regulatory environment

• Identify key city staff needed to participate in PPA process, including technical, financial, and legal experts

• Consider creating a risk committee or working with a third-party expert to review and assess potential financial and legal risks of transactions

• Consider project selection criteria depending on city's short- and long-term interests and goals

• Release a Request for Proposals (RFP) to identify the best potential project that meets most or all of criteria

• Network with other cities who entered similar agreements for best practices

• Determine a provider and develop a contract for construction, electricity rate, and term length

• Involve local stakeholders in decision process

• Identify successes, areas for improvement, and potential next steps for future projects

• Share best practices and lessons learned with internal staff and other cities seeking to procure renewable electricity

2.2.8. Public Private Partnerships (PPP) for Cities

Authored by Ping Yean Cheah, AIIB

Public-private partnerships or PPP is a formal partnership between a public sector entity and a private corporation, which sets the basis to construct and operate infrastructure facilities or develop certain urban areas. In a post pandemic, global economic recovery era, PPPs to most emerging economies can be the solution to narrow the financing gap while mobilising private sector finance and efficiency.

Cities are in a strategic position to optimise PPP financial instruments to fill in funding gaps especially for "green" infrastructure projects. There are basically three pre-requisites to deploying PPP[185]:

a. Risk is well contained
b. Solid return on investment; and
c. Markets for "green" infrastructure projects

Two case studies of PPP model in "green" finance are illustrated below[186].

I. Santiago's public transport electrification – Santiago Chile has a plan to fully electrify its fleet of 7,000 buses by 2035. Measured as cost per kilometre driven, the cost of ownership for electric buses has reached parity with diesel buses, taking into account the e-buses longer service life and lower energy and maintenance costs. However, the upfront capital investment for e-buses can be two or three times that of diesel.

   Santiago adopted a financing structure commonly used in the airline industry i.e., unbundling of fleeting ownership and operations. In this model, Government pays the leases while private sector fleet owners provide buses and charging stations to the operators. Maintenance and ensuring bus stock supply are borne by the manufacturer. Collection of bus fares is done by the Government via pre-paid cards.

   This model protects the lenders from demand risk, technology risk and private operators' credit risk.

In this project, a $129 million loan was extended by Société Générale for 400 over e-buses and the charging infrastructure. The manufacturer is China's BYD, while Metbus, a private operator, runs the buses. Some areas of maintenance, such as mattery packs, are the responsibility of BYD.

Chile has a domestic plan to reach carbon neutrality by 2050 and achieve full grid decarbonisation by 2040. Zero emissions mobility programs like this in Chile complements its plan.

II. PPP model by Morocco to scale up solar and wind power

Morocco has an NDC target to reduce its GHG emissions by 45.5% by 2030. To reduce its dependence on fossil fuel imports, it launched a strategy to bolster the share of renewables (e. g. wind, solar and hydro) to 42% of its generation capacity by 2020, and a higher target to 52% by 2030. This translates to the need to install an estimated 4.6GW of solar and 4.2GW of wind power from 2016 – 2030, costing about $30 billion of investment.

In executing this strategy, the Government established an SOE, i.e., the Morocco Agency for Sustainable Energy (MASEN) that acts as a go-to facilitator for renewable energy developers, with the authority to issue permits, raise financing and acquire land. It prepares competitive tenders for sites and capacities, signs PPAs with IPPs and gets the economy-wide grid operator to buy its electricity. MASEN also mobilises concessional lending through agreements with trust funds and development banks. MASEN can also take equity stake in projects while the Government passed legislation enabling IPPs to develop projects based on corporate PPAs.

All these led to the growth of solar and wind capacity in Morocco from 0.3GW in 2012 to 2.1GW in 2020. Morocco is now exploring other options such as CSP plants with thermal storage, pumped hydro storage, and inter-connectors.

2.2.9. Land Value Capture to Finance Transit Oriented Development

Authored by Ping Yean Cheah, AIIB

The urban setting, with potential land value appreciation, provides an ideal setting to capture future economic value of real estate that will pay for immediate needs of infrastructure construction and subsequent maintenance costs. This idea leverages positive externalities arising from the infrastructure investment, which are monetised and used to financing major infrastructure. Known as 'land-value capture', this model can manifest in the following ways:

a. A contractual agreement with neighbouring real estate owners that quantifies their financial gains from a new infrastructure project. A percentage of the gains will also be reserved for project maintenance
b. Introduction of a special property tax that kicks in once the infrastructure is built to fund continuous creation and improvement the infrastructure
c. Capturing part of the added value on a real-estate sale derived from the new infrastructure

d. Creating local by-laws that regulate all new real estate development to assign a fixed percentage of the costs to a pool fund for the new infrastructure.

The World Bank's City Resilience Program summarises the following benefits of LVC as a policy mechanism for Governments:

a. Funds investment in public infrastructure to reduce physical vulnerabilities e. g. floods, environmental pollution at the same time unlocking land values
b. Secure upfront infrastructure funding by recouping real estate gains generated by the infrastructure upgrade
c. Tax on direct beneficiaries of public infrastructure upgrade, which would otherwise benefit from such improvements as "windfall gains", and
d. Promote infrastructure cost-sharing with win-win outcomes to public and private stakeholders.

The World Bank's Program has provided LVC advisory services and benefitted cities such as:

a. Re-opening of Ahmedabad's riverfront, i.e., 22 km of promenade, involving resettlement of slums, and 202 hectares of land made available for modern development.
b. Re-generation of Rio de Janeiro's historic area where underused industrial land plots in the core of Rio was re-zoned, re-developed and the city earned $1.8 billion from sale of rights to build extra density and the plots became home to 70,000 mixed income residents. The lands were re habilitated into a well-serviced, accessible community hubs[187].

From these two examples, LVC has clearly proven to be a financing policy mechanism that can spur a virtuous circle of value from infrastructure upgrades.

LVCs have also been popularly deployed to finance investments in transit and Transit-On-Demand. In East Asia, two global cities i.e., Hong Kong, China, and Tokyo, provide cases of successful large-scale development based LVC. LVCs have been applied to not only recoup the costs of mass transit construction, operation and maintenance but also to support TOD for sustainable urban development. In Hong Kong, the LVC is manifested via its Rail Plus Property (R + P) program implemented by its subway authority, the MTR Corporation. Under the R + P program, the Hong Kong Government gives exclusive rights of Government land to property developers at a 'before-rail' market price. MTR then captures the land value increment created by R + P, such as accessibility and agglomeration benefits by partnering with private developers to develop the land. The completed development is then sold at an 'after rail' market price. This LVC model successfully recoups capital, operating and maintenance costs of railway projects through sharing profits. It is reported that property development accounted for nearly 40% of MTR's corporate income, while rail operations only for 34%, from 2000 – 2012.

Like Hong Kong, Tokyo offers replicable models in applying development based LVCs to finance railway investments with revenues from property development. The popular LVC model commonly features the landowners partnering a developer to establish a co-operative entity to consolidate piecemeal land parcels into a single site, that they then develop (e. g. high-rise building or mixed used building) with new access roads and public open spaces. The

local Government then modifies the zoning codes and optimises the floor area ratio (FAR) in the targeted re-development district.

Other examples of LVC best practices over the recent decade are Singapore's Marina Bay and the New Elizabeth line east west railway across London, United Kingdom.

As population continues to rise and economic activities recover in Asia's rapidly growing cities, municipals and transport authorities should consider adopting and adapting various development based LVC schemes in their respective local context, to recoup some of their investment, operation and maintenance costs[188].

LVC is described in this report as a possible source of green finance. The above-mentioned examples of LVC financing transit-oriented development (TOD) are likely to satisfy the criteria of greenness (see section 2.1.1) to the extent that mass transit systems are consuming much less energy than individual transport of a same capacity. TOD investments are, therefore, one of the most important investments in energy efficiency. As far as they are not electrified yet (e.g., some bus rapid transit BRT systems), they can be electrified, which adds further to their greenness. Further down in section 3.2.2. it will be explained how urban planning can contribute to limiting energy consumption of cities

References:

World Bank. City Resilience Program slides

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2.3. Overview of Green Financing Instruments

2.3.1. Green Bonds

Green bonds are the most popular and best-known instrument of green finance. As a common practice, they can be affected to green projects of any type of enterprise. Thus, it could be possible that a coal producing enterprise uses green bonds to finance a green project. Green bonds are normally tradable on the securities market.

The first green bonds were issued by the World Bank and the EIB back in 2007. In 2013 the first green bond has been issued by a property company, in this case located in Sweden. The first US State to have issued a green bond was Massachusetts in 2013. The first sovereign bond was issued in 2016 by Poland. Today more than 67 economies issue green bonds or similar green finance instruments. The figure below shows the cumulative progression of green bonds, having now reached the cap of $1 trillion. This is certainly a remarkable result, however the requirement for carbon neutrality would be at $4 trillion per year. Nonetheless, this target seems in reach given the high growth rates.

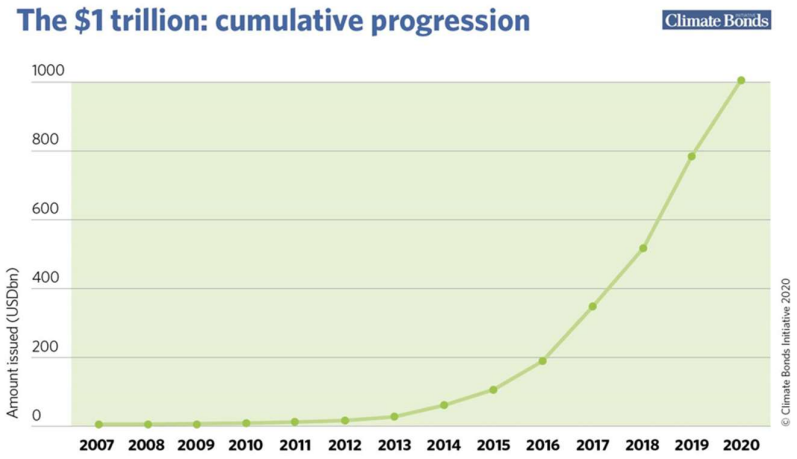

Figure 87: Growth of green bonds

Source: Climate Bonds Initiative

The Green Bond Principles Voluntary Process Guidelines for issuing green bonds, issued in 2021, provide for 100% of the proceeds to be used for the specified purpose (usually a project)[189]. Reporting on the use of proceeds should be done annually.

2.3.2. Green Loans

Green loans are used to channel finance to climate and environmental (green) projects. The World Bank's International Finance Corporation (IFC) is today the largest provider of green loans. Compared to green bonds described in the previous section, the volume of green loans is in general much smaller than for green bonds. Green loans are done in a private operation, whereas green bonds are sold on the open market. Green loans are not listed on an exchange.

The Green Loan Principles (Dec 2018) are voluntary recommended guidelines[190]. They specify that 100% of proceeds of green loans are to be used for the specified purpose.

Total green loans outstanding at IFC are at USD 33 billion, of which only USD 1.6 billion has been lent to developing economies. More information on green loans administered by the IFC in section 2.5.4.

2.3.3. Green Equity

The area of green equity has been rapidly growing since COP26. The use of equity to promote sustainable development, either in projects or in enterprises, should be the most natural way to advance an economy towards carbon neutrality. If it happens this way, it will signal that sustainable economy has become cost-effective and competitive compared to the non-circular economy.

Multi- and bilateral financial institutions are revising their policies or positions on equity investing

- European Investment Bank is consulting publicly on a new Standard 11 on Intermediated Finance
- Asian Development Bank (ADB) is currently reviewing its Energy Policy, which addresses FI investing
- International Finance Corporation (IFC) is reviewing its Approach to Greening Equity
- Asian Infrastructure Investment Bank (AIIB) will begin a review of its Energy Sector Strategy in December 2021.

GCF has accelerated its support for equity investments, primarily through its Private Sector Facility (PSF). Equity investments, including the most recent approval of GCF equity investment support for two large private equity funds supporting adaptation, make up 22.1% of GCF private sector investments and focus on de-risking private sector climate infrastructure projects and programmes and structuring anchor investments in climate equity/debt funds.

In this context, one can remark that equity has "junior" status compared to debt (bonds and loans) which are considered as "senior", hence investing in green equity is a way to de-risk the debtors. This means that an optimal part of equity can have a catalytic effect on attracting debt as supplementary source of finance. This is called the catalytic effect of equity.

Engineering the catalytic effect of equity

The catalytic effect of equity works as follows: Public investors (foundations, high net-worth individuals, government and development finance institutions) invest in so-called catalytic first-loss capital, that is subordinate categories of debt, such as:

- Grants, incl. to cover a set amount of first loss
- Equity: the most junior equity position in the overall capital structure
- Guarantees: A guarantee to cover a set amount of first-loss capital; is like a grant but has a cost
- Junior subordinated debt: The most junior debt position in a company

In doing so, the above-mentioned public investors de-risk senior categories of debt or bonds. This helps attracting the latter who are low-risk investors.

An example of a catalytic fund has been described by the Catalytic Capital Consortium (2019)[191]. The Catalytic Capital Consortium, or C3, aims to demonstrate the power of this form of investment to extend and deepen the reach of the impact investing field, helping to address the annual funding shortfall of $5 trillion to $7 trillion that is hindering the world from reaching the UN Sustainable Development Goals.

Recall that the IEA Sustainable Recovery Plan 2021 – 2023 calls for an increase of global investment in clean energy by about USD 1 trillion per year over three years, equivalent to 0.7% of global GDP in 2019, of which 70% would come from the private sector and 30% from public sources. If this proportion is used within the same project, this kick-off scheme will be implementing the catalytic effect by expecting a catalytic factor of public sources of approximately 3. Sections 2.5.3 and 3.1.4. give further examples of using a catalytic mechanism.

2.3.4. Environmental Insurance

Insurance can play an important role in promoting environmental quality. Examples for this are the different insurances for environmental liability. A prerequisite for insurance to start offering policies on environmental liability is that legislation must state the civil liability of an industrial enterprise for specified types of environmental damage, and the maximum amount of liability for each type of damage.

Examples of environmental insurance are used for technological disasters such as oil spills and nuclear accidents. If the above pre-requisite is met, private or public insurers will be able to offer insurance coverage.

A recent initiative of insurance related to carbon neutrality is the Net-Zero Insurance Alliance NZIA, formed in July 2021 by the 8 global leading insurers signed to “Commit to transitioning its investment portfolios to net-zero GHG emissions by 2050 consistent with a maximum temperature rise of 1.5°C above pre-industrial levels”[192]. NZIA was convened under the UNEP Finance Initiative’s Principles for Sustainable Insurance (PSI)[193]. Similar initiatives have been created by UNEP for the banking sector: Net-Zero Banking Alliance NZBA[194], created in April 2021 by 43 founding banks representing over 40% of global banking assets; these and other initiatives have also been mentioned in section 2.2.4. above.

2.3.5. Guarantees Supporting Green Investments

Guarantees are prime instruments to reduce risk. They have existed for a long time and are not specifically provided for reducing risks of the green investments. Providers of guarantees for green investments are:

- governments
- green investment entities and
- green banks

An example for one of the best-known international guarantee institutions to reduce risks is the Multilateral Investment Guarantee Agency MIGA related to the World Bank. In its traditional business, the MIGA insures foreign direct investments against losses related to:

- Currency inconvertibility and transfer restrictions
- Expropriation
- War, civil disturbance, terrorism, and sabotage
- Breach of contract
- Non-honouring of sovereign financial obligations

MIGA also provides dispute resolution services for guaranteed investments to prevent disruptions to developmentally beneficial projects. More recently, the MIGA has started to support sustainable investment[195]. Its performance standards comprise the following elements:

- social and environmental assessment and management
- labour and working conditions
- pollution prevention and abatement
- community, health, safety and security
- land acquisition and involuntary resettlement
- biodiversity conservation and sustainable natural resources management
- indigenous peoples
- cultural heritage

Another example of an agency granting guarantees for green investment is the European Investment Bank's EIB Project Bonds Credit Enhancement and the Project Bond Initiative of 2012[196]. Its objective is to attract capital for the European transport, energy, information and communication networks (infrastructure). It has been recognized that Green Investment Guarantees should be adapted to cover the specific risks of green investments so that they can fulfil the specific objective to attract capital for an economy-scale green investment plan.

Yet another example is given by the Interamerican Development Bank. In 2014 it published the "Guarantees for Green Markets: Potential and Challenges"[197].

The solar energy world has been waiting for a risk mitigation tool specifically for solar power. This had been announced for the first time at COP21 in 2015 under the name of Terrawatt[198]. This initiative aims at implementing the "well below 2°C" target of the Paris Climate Agreement by bringing down the renewable energy cost to "well below 2 cents/kWh". Coupled to the International Solar Alliance, the framework should be realized under the name Solar Alliance Risk Mitigation Initiative SRMI, launched at COP24 in 2018, and should be a $1 trillion scheme[199]. The Solar Deployment Guidelines + e-Tendering platform have, however, not yet been implemented.

An example of an economy-wide green credit scheme that is in force is Sweden's state credit guarantees for investment in green industry, launched in June 2021. Guarantees are issued by the Swedish National Debt Office, covering loans bigger than SEK 500 million, guaranteeing up to 80% of the loan and having a maximum maturity of 15 years[200].

2.4. Examples of De-risking Green Investments

2.4.1. Green Credit Guarantee Schemes and Similar De-risking Instruments

Authored by Farhad Taghizadeh-Hesary, Tokai University

The lack of long-term financing, the low rate of return, the existence of various risks, and the lack of capacity of market players are major challenges for developing green energy projects. Due to the associated risk and due to the Basel capital requirements, many banks are reluctant to finance green energy projects (Taghizadeh-Hesary and Yoshino, 2020). It is essential to take the necessary steps to mitigate the risks of green financing to unlock the

participation of financial institutions in these projects (Yoshino and Taghizadeh-Hesary, 2018). One solution is incentivizing non-banking financial institutions (NBFIs), such as pension funds or insurance companies, to engage in green energy projects. The advantages of pension funds and insurance companies over banks are that these institutions pursue asset-liability matching, and their resources are long-term (10, 20, or 40 years). Insurance companies or pension funds can finance green infrastructure projects, including large green energy projects such as large hydropower, as they are long-term projects (10 – 20 years). Therefore, developing pension funds and insurance companies in developing economies is very important to fill the financing gap of infrastructure projects, including energy and green energy projects (Taghizadeh-Hesary and Yoshino, 2020).

Another method is utilizing the role of the credit guarantee scheme. Credit Guarantee Corporations (CGC) are public institutions that support those sectors that lack access to finance (SMEs, start-ups etc.) by serving as guarantors to make it easier for them to borrow the funds necessary for their business operations from financial institutions. Credit Guarantee Schemes (CGSs) have been used in many economies and in various forms over the decades to increase the flow of funds to targeted sectors and segments of the economy, including SMEs. A CGC makes lending more attractive by absorbing or sharing its associated risks. A CGC can also increase the amount of funds lent to enterprises beyond its collateral limits because the guarantee is a form of collateral. A CGC can assume the additional role of loan assessor and monitor and thereby improve the quality of lending (Zander et al., 2013). But guarantee funds have a cost, which is paid by fees charged and/or subsidized by the government or a third-party institution.

According to Mankiw (1986), a credit guarantee aims to mitigate inefficient credit allocation caused by information asymmetry between borrowers and lenders. The reduction of information asymmetry is an intermediate goal of establishing credit guarantees, and the government's ultimate goal is to provide the desired level of loans to SMEs, by reducing information asymmetry.

CGSs were used in several economies, at least from the early 20th century (Beck et al., 2008). Japan was an early innovator. CGSs spread first throughout Europe and the Americas in the 1950s and then to Africa, Asia, and Oceania in the 1960s and 1970s (Zander et al., 2013). In 2011, there were 8402 credit guarantee institutions worldwide (ADB, 2014).

Many economies, such as Japan, previously had full guarantee schemes that covered 100% of the default cost incurred by borrowers (Uesugi et al., 2006, Yamoria, 2015). However, before the COVID-19 pandemic, the Japanese government has revised its policy and implemented a partial credit guarantee, as the full guarantee creates a moral hazard—when government covers the full default costs and absorbs the full risk, the lending institution has little incentive to assess and monitor the healthiness of the borrower. This can raise the number of nonperforming loans in the banking system and reduce the productivity of public reserves. Hence, partial credit guarantee schemes can be an optimal model. The guarantee can provide a substitute for collateral-based lending. In the wake of the Covid-19 pandemic, some governments, such as the Japanese government, implemented full guarantee coverage to help the vulnerable sectors survive.

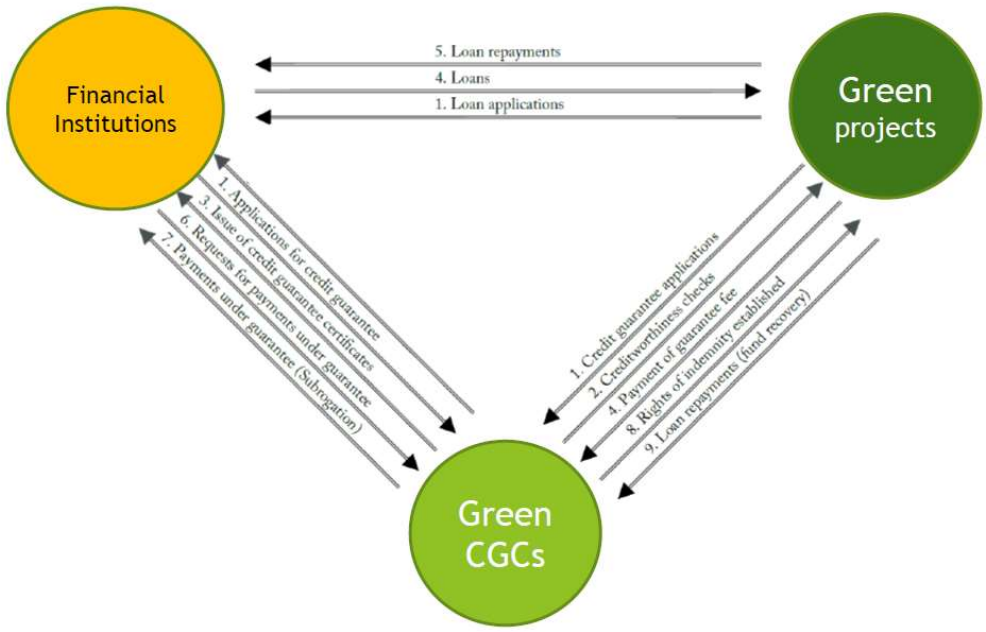

Figure 88: Green Credit Guarantee System flow of operation

Source: Author's depiction

Taghizadeh-Hesary and Yoshino (2019) theoretically used the idea of CGS for the green sector and named it Green Credit Guarantee Scheme (GCGS), see figure above. The GCGS to low-carbon projects will reduce the asymmetry of information and reduce the expected default losses because the green credit guarantee corporation guarantees a portion of a loan default; therefore, banks would like to lend money to those guaranteed low-carbon projects.

In the usual cases of lending to green projects, an adverse loan supply can be observed, as shown in the figure below, by a backward bending loan supply curve. Because of the asymmetry of information between green projects and banks, when lending to green projects, banks set the interest rate much higher than when lending to large enterprises; moreover, they are not interested in lending much money to risky green projects. This explains the backward bending green projects loan supply curve. However, credit guarantees to green projects reduce the asymmetry of information, and hence the expected default losses as a portion of loan default is guaranteed by the credit guarantee corporation (government); therefore, banks would like to lend money to those guaranteed green projects. The dashed line in the figure below shows the loan supply curve if there is a credit guarantee scheme. If the guarantee ratio increases, the dashed line will be flatter, which means more accessible finance for green projects because banks will be more interested in lending to them.

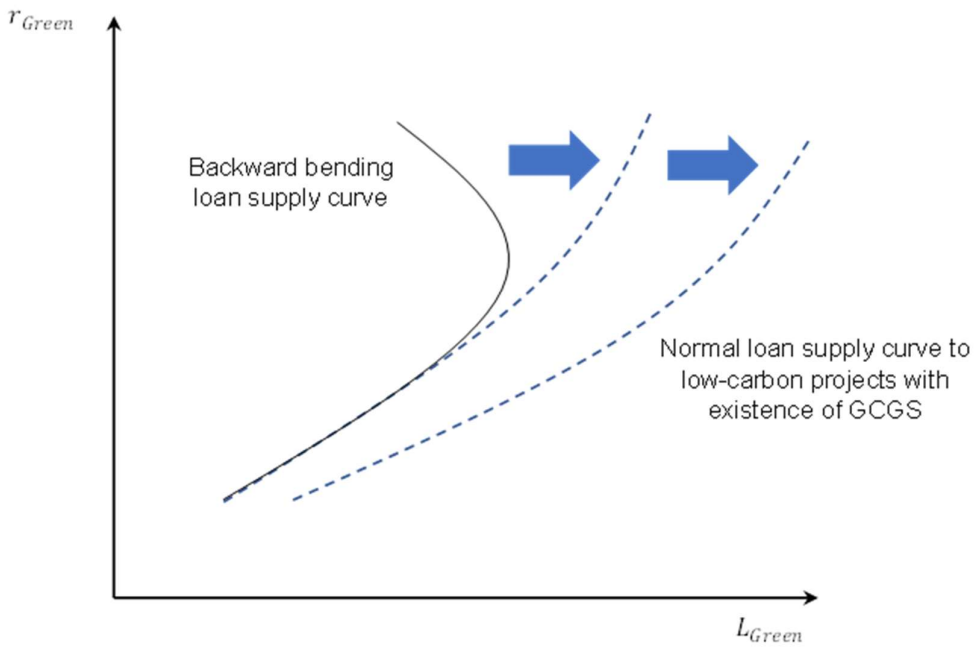

Figure 89: Green credit guarantee scheme and loan supply to low-carbon projects

Source: Author's depiction

Note: rGreen = lending interest rate to green projects; LGreen= amount of loan to Green projects

A GCGS makes it easier for banks to lend to green projects because if a green project defaults, the GCGC will cover a large share of the lender's losses. For example, if the guarantee ratio is 80%, the bank can recover 80% when a green project defaults. Without a guarantee, the bank might not be able to recover any portion of the loan (Taghizadeh-Hesary et al., 2021).

However, three questions need to be answered and considered to have an optimal GCGS that does not rely on the annual government budget and be financially sustainable (see figure below).

First, what is the optimal credit guarantee ratio (i.e., the share of the loan covered by the guarantee) to achieve the government's goal of minimizing banks' nonperforming loans to green projects and simultaneously realize its objective of supporting green projects?

Second, will the ratio be constant regardless of macroeconomic conditions?

Third, should the ratio be the same for all banks, or should it vary depending on a bank's financial soundness?

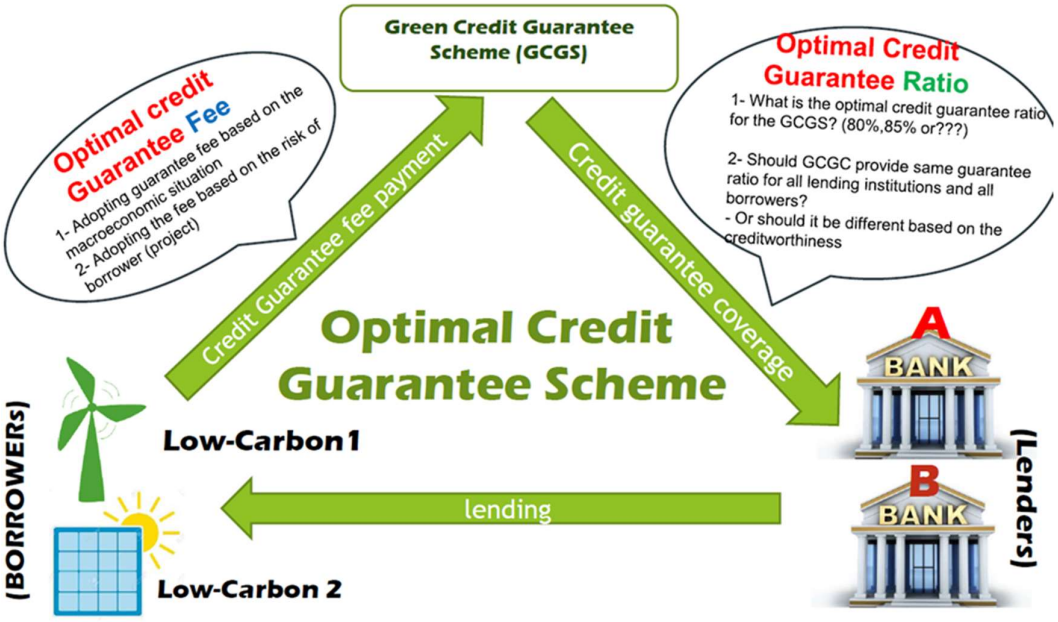

Figure 90: Optimal credit guarantee ratio based on the creditworthiness of borrowers and lenders

Source: Author's depiction

Yoshino and Taghizadeh-Hesary (2019) and Taghizadeh-Hesary et al. (2022) answered these questions theoretically and empirically:

Based on their studies, the credit guarantee ratio depends on three factors: (i) the financial soundness of the lender (bank), (ii) the economic climate, and (iii) the policies of the state for supporting green projects. Economically, sound lenders may access a higher guarantee ratio, while a more appropriate economic climate and government policies may lower the guarantee ratio. Adopting the same credit guarantee ratio for all banks will create a moral hazard.

The optimal credit guarantee ratio should vary for different economies based on the macroeconomic climate and for each bank or, in other words, for each group of banks based on their financial soundness, see figure above. To this end, the following practical policy implications are recommended:

i. Governments should give a higher guarantee ratio to sound banks, while less healthy banks should receive a lower guarantee ratio. This policy helps the financial mechanism to become more efficient and transparent. Through this policy, the governments can encourage less-healthy banks to promote their financial soundness and stimulate sound banks to contribute more to economic growth and performance (Taghizadeh-Hesary et al. 2022).

ii. Furthermore, since the macroeconomic variables have more significant impacts on the optimal credit guarantee ratio in the long run, in the wake of COVID-19, governments should increase the green credit guarantee ratio to ensure the access of green projects to funds. Then, gradually, the ratio needs to be lowered by moving to the new normal stage.

iii. Another policy implication is establishing a regional credit guarantee scheme (RCGS). RCGS could enhance regional's cross-border financial transactions, increase cooperation, economic integration, and cross-border trade, and enhance green growth (Taghizadeh-Hesary et al. 2022).

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2.4.2. Green Finance Instruments of a Commercial Bank

Authored by Kate Xinju Zou, China Construction Bank Corporation

China Construction Bank Group (CCB, the Group) actively participates in the New Finance actions, providing financial solutions based on the economic and social development and customer needs. While the Group is experiencing steady development of each business, it strives to become a bank that serves the public and promotes people's livelihood, low-carbon development, environmental protection and sustainable growth. In 2021, the Bank established

a Leading Group for Carbon Peaking and Neutrality to coordinate and promote the green and low-carbon transformation in service, economy and society as well as advancing the fulfilment of the Carbon Peaking and Neutrality goal. Our MSCI ESG rating continued to climb up and achieved an A rating for two consecutive years, maintaining a leading position in the domestic banking industry.

Green Finance

The Bank continuously optimises the operation and management system and made active improvements in related fields including organisational promotion, policies, support and guarantee, evaluation and incentives as well as supervision and inspection to enhance effectiveness. Furthermore, the Bank has strengthened environmental and climate risk management and control, promoted green and low-carbon transformation of credit structure, integrated environmental and climate risk into the overall credit process management, coordinated energy safety and management and control over industries with high energy consumption and high carbon emission, and implemented climate risk stress testing in an orderly manner. In 2021, the Bank continued to increase the offering of green loans and continuously enriched the portfolios of products and services related to green finance to contribute to the green transformation in the economy and society.

Figure 91: Clean energy development promoted by CCB green finance

Source: China Construction Bank

Performance

The Bank continued the progress in improving the long-term mechanism for green finance development, coordinated efforts in the Carbon Peaking and Neutrality action plan, leveraged the advantages of financial technology and fully licensed finance, actively explored new products, new services and new initiatives for the development of green finance, and utilised a combination of financial instruments, including green credit, green bonds, green leases, green trusts, green insurance and green wealth management, to extensively support and foster green industries.

In 2021, the Bank's green loans maintained rapid growth momentum. As of the end of December 2021, the balances of green loans were RMB1.96 trillion, an increase of 35.61% from the previous year.

The Bank explored innovative and sustainable financial practices, focused on green business development in non-credit areas, formulated the *Implementation Plan for the Expansion of Green Capital Market*, and strengthened the issuance and investment of green bonds. In 2021, the Bank simultaneously issued multi-currency ESG-themed bonds abroad, including US$1.15 billion of sustainability-linked bonds and EUR0.8 billion of green bonds for water protection and environmental governance, and 2-year RMB2 billion offshore transformation bonds, attracting a variety of global socially responsible investment and sustainable finance investors. In December 2021, the Bank issued the world's first demonstrative green bond of US$0.5 billion abroad based on the *EU-China Common Ground Taxonomy - Climate Change Mitigation*, with the raised funds earmarked to support high-quality projects of clean transportation and clean energy in the Greater Bay Area. In 2021, the Bank underwrote 72 domestic and overseas green and sustainability-linked bonds totalling RMB124,037 million, including the market's first batch of carbon-neutral bonds, sustainability-linked bonds, the first green REITs in the interbank market and the green bond dubbed as Lotus Bond. The Bank initiated more than 300 investment transactions in green bonds, boosting more than RMB130 billions of direct green financing.

The Bank actively promoted the development of green investment and financing business of its subsidiaries. CCB Principal Asset Management has officially joined the UN Principles for Responsible Investment ("UN PRI") and issued multiple ESG-themed products. CCB Wealth Management issued ESG-specific wealth management products ("WMPs") to increase investment in green assets. CCB Life, CCB Futures and other subsidiaries continued to increase allocations of various green assets. By the end of 2021, CCB Financial Leasing was the first company in the industry to build a "green leasing" brand and has granted a total of over RMB100 billion in green leasing.

Case story 1: low-carbon living model

To cope with pain points such as difficulties in measuring the carbon emission reduction in low-carbon scenarios and the lack of effective data support for green financial products on the consumer side, the Bank gave full play to financial technologies to create a low-carbon living model, innovated in individual carbon footprint products, providing personal financial services such as discounts on credit card consumption, payment discounts, and points redemption, to explore diversified carbon inclusive mechanisms and lead the green and low-carbon development. The Bank's case of Comprehensive Green Financial Services Based on Carbon Ledger was successfully selected by People's Bank of China as the pilot project for integrated application of financial data.

In terms of application innovation, the project integrated and analysed low-carbon data from various ecological scenarios, such as travelling, retail and government administration through multi-party data learning and other technologies, to realise cross-entity application of the data with complete protection of user privacy and security. The project built a carbon emission reduction measurement model based on artificial intelligence, big data and other technologies to accurately measure consumers' low-carbon footprint and provide model support for the Carbon Ledger. By adopting cloud computing and other technologies, the project built a SaaS (Software as a Service) platform covering carbon emission reduction measurement, Carbon Ledger operation and equity exchange to enhance comprehensive financial services for low-carbon scenarios.

In terms of risk prevention and control, the project accessed a wider range of hot data through the digital management method of building an ecosystem, setting up scenarios and

expanding the user bases. The Bank diversified the data support dimension for low-carbon level measurement and improved the carbon emission reduction measurement model to ensure the authenticity and validity of the Carbon Ledger.

In terms of the practice performance, as of the end of 2021, the project had been piloted in five cities, including Beijing, Shanghai, Shenzhen, Zhengzhou and Qingdao, and completed the carbon emission reduction measurements in eight low-carbon scenarios, such as travelling by underground or bus, ETC payment and utility bills payment.

Case story 2: CCB-Wind Green ESG Bond Issuance Index and Yield Curve

On May 20, 2021, CCB, together with Wind Information Co., Ltd. and International Institute of Green Finance of Central University of Finance and Economics ("CUFE"), released the CCB-Wind Green ESG Bond Issuance Index and Yield Curve Project simultaneously in Beijing and Luxembourg.

As one of the largest leading underwriters of credit debts in the Chinese interbank market, the Bank adheres to the New Finance concept and practises high-quality development. It utilises professional advantages and market influence to research and develop the CCB-Wind Green ESG Bond Issuance Index and Yield Curve, which provides market issuers and investors with an important reference for pricing trends and improves the green bond price discovery mechanism.

CCB-Wind Green ESG Bond Issuance Yield Index evaluates and selects the benefits of carbon emission reduction, green development and sustainable development of newly issued bonds by extracting the primary market yield data of the newly issued bonds every week in the Inter-Bank Bond Market, Shanghai Stock Exchange and Shenzhen Stock Exchange. It classifies and averages the weighted sample data meeting the screening criteria to form an index. On the premise of sufficient sample size, sub-indexes such as the carbon-neutral bonds, green bonds and ESG bonds are calculated and formed in the same way, and the index curve is publicly displayed.

The CCB-Wind Green ESG Bond Issuance Index combines the Bank's green bond underwriting and issuance experience with relevant green bond standards and ESG rating methodologies. It is the first cross-market green bond index after the release of the unified green bond standards in China as well as the first green bond issuance index in the Chinese primary market that integrates ESG and carbon neutrality, filling the gap of the lack of green ESG bond issuance index in the Chinese primary bond market.

On December 4, 2021, CCB's innovation project CCB-Wind Green ESG Bond Issuance Index and Yield Curve won the IFF Global Green Finance Award, ranking first among the Top 10 Innovation Projects of IFF this year. The award aims to commend and reward global green finance and innovative solutions with great global authority and international influence.

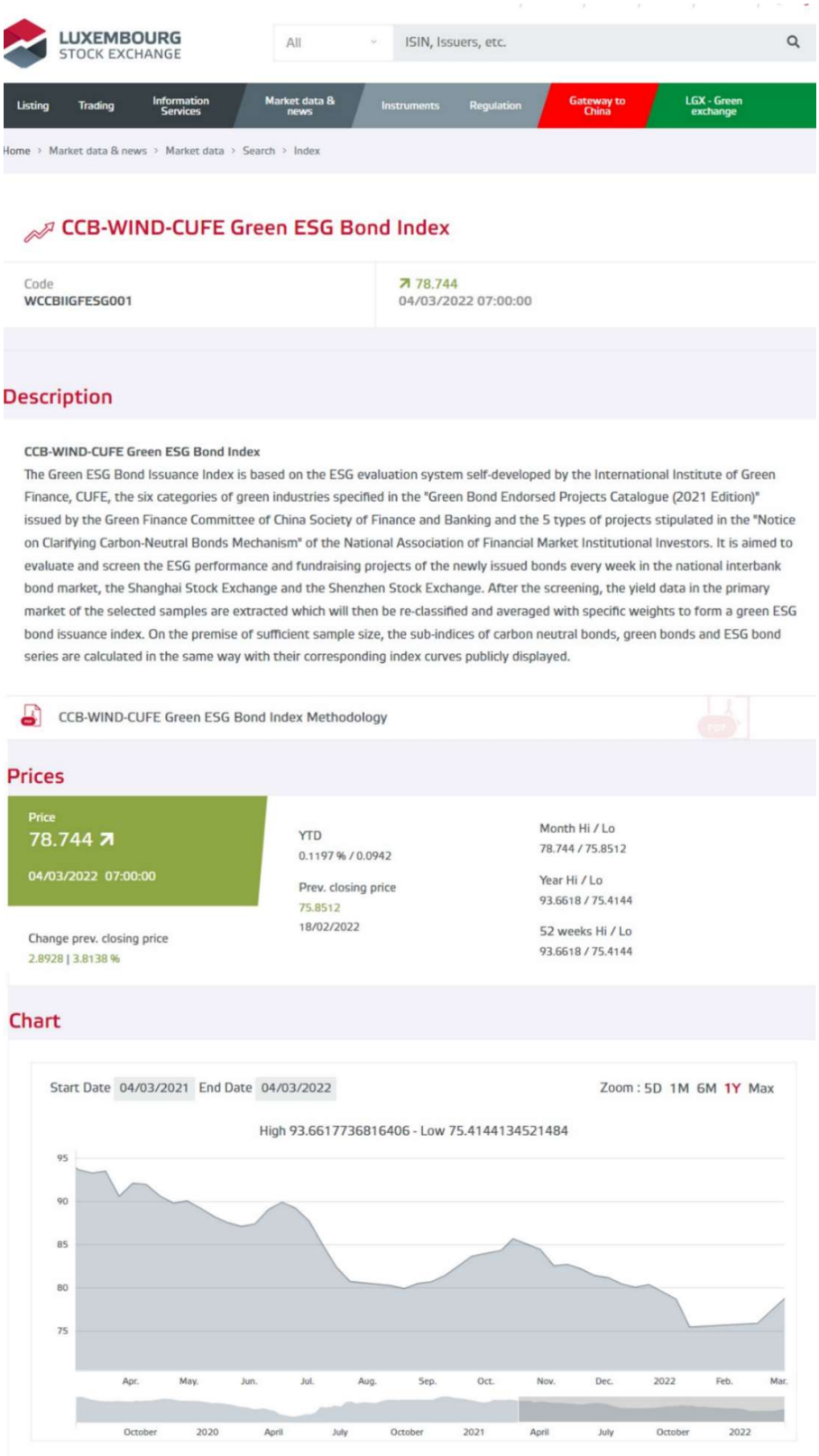


Figure 92: CCB-Wind Green ESG Bond Issuance Yield Index

Source: China Construction Bank

Stress Testing

In May 2021, the Bank became a supporter of the Task Force on Climate-Related Financial Disclosures ("TCFD") and promised to conduct climate change risk response and environmental information disclosure based on the TCFD framework.

According to the classification of climate risks by TCFD, the Bank identified actual or potential acute and chronic physical risks, as well as transition risks due to policies, laws, technologies, markets and reputation. The Bank actively carried out quantitative analysis of climate risks and initiated the construction of a client ESG rating system throughout the Bank to support the healthy and sustainable development of green finance.

In 2021, the Bank continued its exploration on climate transition risk stress testing. It participated in a climate risk stress test organised by the Central Bank of China, and completed three sectoral stress tests, including thermal power, steel and cement, to assess the potential impact of the transition of carbon peaking and neutrality target on the Bank's credit assets. The Bank has also conducted climate risk stress tests for the aviation industry.

In 2021, the stress tests mainly focused on the Bank's corporate clients in the thermal power, steel, cement and aviation industries with annual emissions of more than 26 thousand tonnes of carbon dioxide equivalent (according to the Ministry of Ecology and Environment's criteria for defining key greenhouse gas emitters). The Bank examined the potential impact on the repayment capability of the above enterprises assuming that they were required to pay a certain carbon dioxide emission expense. By carrying out stress tests over ten years, setting end of 2020 as the base day, the Bank launched tests in three stress levels, mild, moderate, and severe, according to the changes in the carbon prices in the domestic carbon trading market and carbon price situations of the Central Banks and Supervisors Network for Greening the Financial System (NGFS). Assuming that the enterprises would not undertake low carbon transition during the test period and had no bargaining capability over upstream and downstream enterprises, the Bank adopted the international mainstream methodology to test each enterprise and quantitatively assess the impact of climate transition risks on the financial costs and credit ratings of clients.

The test results showed that the repayment capabilities of the clients in thermal power, steel, cement and aviation industries were reduced to varying degrees under stress scenarios, resulting in corresponding credit rating downgrades, yet the risks were generally controllable. Among them, the thermal power, steel and cement industries were greatly affected, with the Bank's capital adequacy ratios declining by 0.86, 1.15 and 1.35 percentage points, respectively by 2030 under the three stress levels (i.e., mild, moderate, and severe). However, due to the low proportion of loan balances of each industry, the impact on the Bank was limited, and the declined capital adequacy ratios were all higher than the regulatory requirements.

The Bank has carried out special training on environmental and climate risk stress testing across the Bank, invited internal and external experts to comprehensively educate the concept of environmental and climate risk, future development trends, domestic and foreign practices and stress testing mythology and tools. The Bank has comprehensively strengthened the training of relevant leading members of the Head Office, branches and subsidiaries, and provided team and capacity support for the orderly promotion for the Carbon peaking and Neutrality work.

Environmental and climate risk response

The Bank issued the *Notice on Strengthening Environmental and Social Risk Management, the Notice on Strengthening the Environment and Climate Risk Management of Credit*

Business and the *Notice on Strengthening the Management of Credit*, *Investment and Financing for Industries with High Energy Consumption and High Carbon Emission* to define the policies for environmental and social risk management, support the technique upgrade of energy conservation and decarbonisation in core industries and companies to step up risk prevention and mitigation efforts. The Bank has set a series of development objectives to accelerate the development of green finance new advantages and reviewed the credit policies for relevant industries like photovoltaic power generation, photovoltaic manufacturing, steel, petroleum refining, railway etc. For major industries and environmentally sensitive industries such as power, transportation, green building, agriculture, forestry, mining, petrochemicals, steel and so on, the Bank has also incorporated environment-related regulatory requirements in the industry-specific credit policies to actively support green development and control environmental risks.

To cope with risks associated with climate change, the Bank has formulated environmental and climate risk management policies for all corporate credit clients, in which it has incorporated environmental and climate risks into the overall credit management process. The Bank has specifically considered projects with high energy consumption and carbon emission under the list for prior management, and incorporated key factors like energy efficiency, greenhouse gas emission and pollutant emission during the selection of clients and projects, credit approval and post-loan management.

Green Operations

The Bank attaches great importance to green operations, including continuously improving the management systems for energy conservation and environmental protection, strengthening the implementation of energy conservation and emission reduction measures, perfecting the systems of monitoring and diagnosis, energy audit and maintenance, and establishing a categorised statistical ledger to regularly collect energy consumption data for analysing energy consumption indicators and strengthening maintenance to deepen the energy conservation potential; implementing green office by turning off lights and computers in time to reduce standby consumption; accelerating intelligent operations by utilising technologies to promote paperless office, reducing the use of disposable office supplies and increasing the use of video conferencing systems; encouraging energy-saving technology renovation with efficient and eco-friendly equipment; initiating the Clean Your Plate campaign and promoting the applications of information management platforms like Smart Canteen; implementing a standardised waste recycling mechanism, procuring from professional recycling companies and carrying out the UPS battery recycling services across the Bank; introducing recycling mechanisms for various products such as Smart POS and QR scanning terminals; promoting concept of green environmental protection as well as knowledge on energy conservation; advocating a low-carbon lifestyle to enhance the employees' awareness of energy-saving, and encourage customers and the public to participant in low-carbon and environment-friendly activities like the CCB Low Carbon Living Month and Earth Hour.

The Bank has set up a Carbon Footprint Management Group to comprehensively review the Bank's energy and resource consumption, including electricity, natural gas, diesel, gasoline, heat, LPG, coal, water and paper, from 2016 to 2021. Together with carbon emission experts, the Bank has studied and formulated statistical standards for energy consumption and continuously and steadily promoted the Zero-Carbon pilot projects to build a low-carbon bank. The Zhongshan Cuiheng New Zone Sub-branch of Guangdong Branch has become the first Zero-carbon Outlet in the industry and was awarded a carbon neutrality certificate by the China Emissions Exchange (Guangzhou). The Head Office of the Bank has been evaluated as Excellence in the energy-saving target assessment in Xicheng District of Beijing for three consecutive years.

Green Procurement

The Bank incorporated green and environmental protection, energy-saving and emission reduction policies into the procurement system, which stipulated in the *Supplier Management Regulation and Management Measures for Centralised Procurement* that “priority shall be given to suppliers with energy-saving and environment-friendly products” and “energy-saving and environment-friendly products”, respectively.

For supplier selection, the Bank asked to strengthen the approval of environmental protection qualifications and prioritize suppliers with energy-saving and environmental protection or green qualifications. The Bank has also increased the weighting of energy-saving and environmental protection-related indicators in the model selection test and procurement evaluation. In terms of recycling and disposal, the Bank has encouraged the recycling of waste materials and taking the lead in regulating the recycling of waste batteries.

The Bank attaches great importance to the green transition of vehicles and actively follows the development direction of new energy vehicles in the 14th Five-Year Plan. In 2021, the Bank took the lead in the banking industry to propose and implement centralised procurement, replacement and configuration of new energy vehicles, optimising the allocation ratio of new energy vehicles and fuel vehicles. The new energy vehicles purchased accounted for 50% of the year.

Green Finance Governance – the Board of Directors

The Board of Directors (the Board) of the Group is responsible for formulating the Group’s ESG and green finance strategy, defining the strategic objectives and priorities, promoting the management of significant matters, overseeing and evaluating the effectiveness of the ESG strategy, and guiding the disclosure of relevant information; introducing a series of ESG strategic initiatives to integrate ESG concepts into business operations, so as to promote the sustainable development of economy and society; urging the Management to implement green development concept and monitoring the progress on green finance regularly.

The Related Party Transaction, Social Responsibility and Consumer Protection Committee is set up under the Board, responsible for formulating ESG management policies and strategies, management on green finance strategy. The Risk Management Committee under the Board has incorporated the risk management of ESG-related factors into the Bank’s comprehensive risk management system to assist the Management in accurately identifying and effectively managing significant ESG-related risks. In 2021, the Risk Management Committee promoted the Management to strengthen the forward-looking management of environmental and climate risks by expanding the coverage of climate risks stress tests; optimised the credit policies for environmentally sensitive industries by incorporating environmental and social risk factors into the corporate credit rating; explored to construct an ESG assessment system for clients and improved risk assessment and pricing capabilities related to ESG factors; established a reporting mechanism for ESG-related risks to, listen to regular reports on key tasks such as environmental and climate risk analysis and quantitative risk analysis of ESG-related factors and to provide guidance.

Green Finance Governance – The Board of Supervisors

The Board of Supervisors performs its supervisory duties and incorporates the Group's ESG-related work and the construction of a green financial system into its annual supervisory priorities. The Finance and Internal Control Supervision Committee, within which listened to the report on the implementation of green credit and proposed suggestions around green finance development plans and seizing market opportunities to speed up structural adjustment

in support of the Carbon Peaking and Neutrality goal and green transformation. A number of supervisors have attended special training sessions on carbon neutrality and green finance to keep abreast of the latest developments of green finance and other relevant information.

Green Finance Governance – The Management

The Management is responsible for formulating the ESG objectives and plans and promoting the implementation. On the environmental front, the Management has set up the Green Finance Committee, which is responsible for the Bank's green finance development. In 2021, the Green Finance Committee convened three meetings where attendees discussed key management tasks related to green finance and promoted key measures for cultivating competitive edges in green finance.

To enhance risk management, the Management has set up the Risk Management and Internal Control Management Committee, chaired by the President, to incorporate ESG factors into the business operation and risk management process and include environmental and climate risks into the comprehensive risk management system. In 2021, the Bank established the ESG Promotion Committee to coordinate and promote the Group's overall ESG strategy planning, implementation and coordination.

In terms of policy application, the Bank formulated the Action Plan for Carbon Peaking and Carbon Neutrality in Full and Faithful Implementation of the New Development Philosophy and the Strategic Plan for Green Finance Development (2022 – 2025) and put forward the vision of striving to become the world's leading sustainable development bank. The Bank proposed to implement the Five Projects of green finance focusing on the areas of business development, product innovation, risk management, technology application and internal operation, with top priorities emphases the 15-Action such as promoting the green and low-carbon transformation of energies and supporting industrial pollution cut and carbon reduction. The Bank also made steady efforts to promote the green and low-carbon transformation, striving to drive the building of the new pillar, green finance, towards high-quality development and making it a new strength to win the market competition. The Leading Group for Carbon Peaking and Neutrality held a work meeting in 2021 to formulate the 20-Action Plan to achieve carbon peaking and neutrality, so as to promote green and low-carbon transformation.

In terms of performance assessment, the Bank included the Supporting the Ecological Civilisation Strategy as one of the Management performance indicators, expanded the scope of green finance assessment in the quantitative assessment of Head Office departments and increased the weight of green finance among the performance assessment indicators for tier-1 branches to promote high-quality development of green finance. The Bank have fully implemented the audit supervision system, with periodic internal audits conducted for different business segments in a risk-oriented manner to improve the risk management performance.

2.4.3. Green Bonds for Energy Efficiency

Authored by Xiaotong Gao, APEC CNSC Program Joint Operation Center

After entering the twenty-first century, the energy consumption of China's construction sector has increased rapidly. Public buildings are an important part of the construction industry, and their energy consumption intensity is much higher than that of civil buildings. According to the China Building Energy Consumption Research Report 2020, the public building area accounts for 19% of the total building area, but the building energy consumption accounts for

38%. It can be seen that China's public buildings have high energy consumption and great energy-saving potential. Energy conservation and emission reduction are imperative in China.

In recent years, relevant departments have also issued corresponding policies on energy conservation and emission reduction. However, the energy efficiency of public buildings faces some difficulties, such as financing problems. Energy efficiency improvement requires a large amount of capital investment in the early stage, and at the same time, most owners lack the necessary financing channels.

The key to promote the energy efficiency of public buildings is to solve financing problems. As a new green financial product, green bonds provide a new financing channel for the development of green buildings.

"Green bond" refers to a bond instrument that uses the obtained funds to finance or refinance green projects that meet the specified conditions. It can provide various benefits: it can provide new financing channels other than traditional credit for green projects; Green bonds are generally highly rated and fevered by investors. Compared with ordinary bonds, they have a certain issuance premium; It Provides more long-term investment for green projects; it can also Encourage the issuer to continually invest its income in green projects, and actively develop new green projects.

With the rapid development of green finance, green bonds also usher in opportunities for development. China's green bonds started late but developed fast. Over the past two years, China has issued over 15. billion yuan of bonds invested in green buildings.

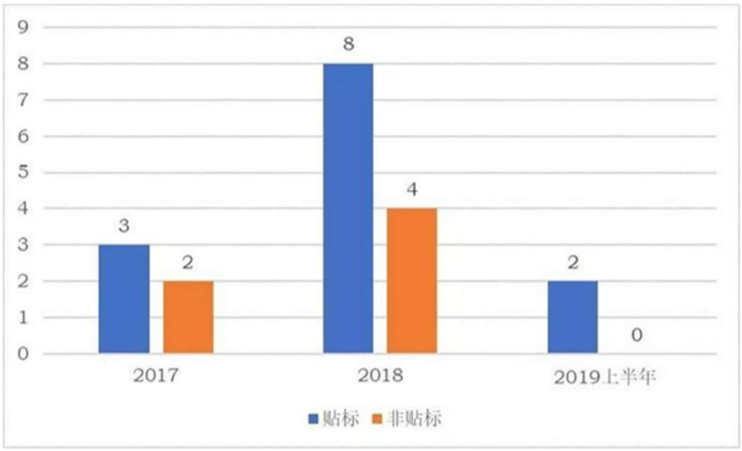


Figure 93: Number of Green Building Bonds Issued in China's Green Building Bond Market from 2017 to the First Half of 2019 (Unit: Piece)

Source: CNSC Program Joint Operation Center

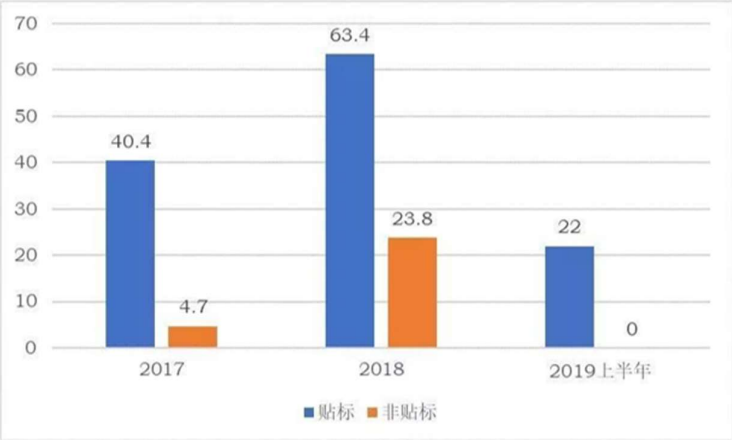


Figure 94: Green Buildings in China from 2017 to the First Half of 2019 Issuance Scale of Bond Market (Unit: 100 million Yuan)

Source: CNSC Program Joint Operation Center

Based on the research background just mentioned, the research content of this study mainly includes the following three points:

Firstly, we carried out energy efficiency technology demonstration

Through the financing scheme and cost-benefit analysis of green bonds of Qingdao Haitian center, we summarize the successful experience and implementation scheme of green financing of the project

By studying the evaluation methods and indicators of the green benefits of this project, we summarized the market-oriented financing model of China's green finance, to support the energy efficiency of public buildings.

The Qingdao Haitian Center T2 Tower Building is composed of international banquet and Conference Center, hotel and high-end Seaview apartment. It's about 370 meters high, with a total investment of 13.7 billion yuan. It's the first super high-rise building in China to effectively solve the project financing needs with green bonds.

Figure 95: Introduction to Demonstration Project: Qingdao Haitian Center T2 Tower Building

Source: CNSC Program Joint Operation Center

Through preliminary design optimization, energy consumption simulation and economic analysis, the project has determined 10 key energy-saving technologies:

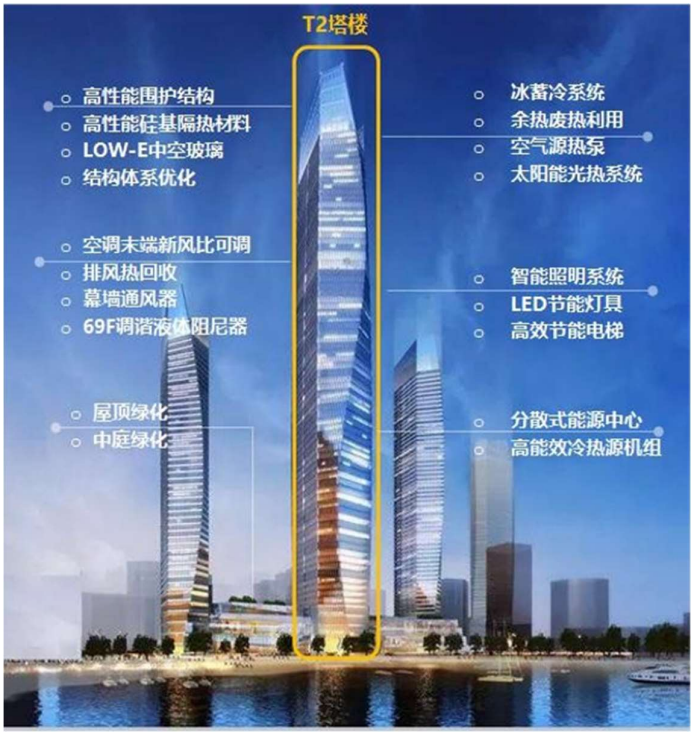


Figure 96: Summary of Technical Highlights of Demonstration Projects

Source: CNSC Program Joint Operation Center

High performance envelope: Double hollow Low-E glass, external window heat transfer coefficient is 15% higher than the reference building.

Curtain wall ventilators: Curtain wall ventilators are set on each floor below the 18th floor to enhance the indoor ventilation effect.

High efficiency cold and heat source unit: The energy efficiency of cold and heat source units is about 5% better than the current economy-wide standard.

Air conditioner with adjustable fresh air ratio: The variable fresh air ratio and fresh air operation can be realized in the transition season, and the maximum total fresh air ratio can be greater than 50%.

Ice storage system: Compared with the conventional refrigeration system, the operating cost of the air conditioning system in the whole summer decreased by 27.19%.

Energy Center: Four energy centres are set up to manage energy consumption.

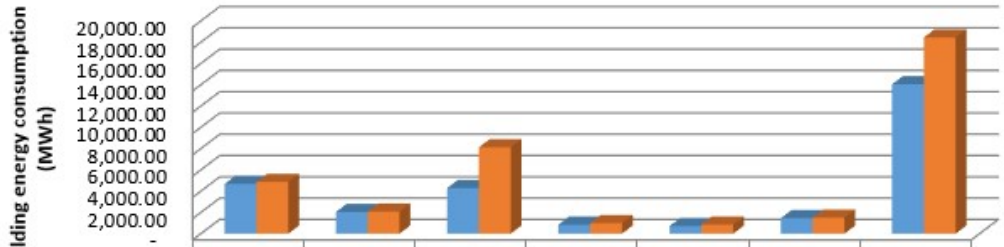
Energy saving lamps and intelligent lighting: Energy saving light sources such as LED are used for indoor lighting, and intelligent lighting system is used in public places.

Energy saving elevator: Elevator group control, escalator automatic start and stop, energy feedback, no segment speed control technology.

Waste heat recovery and utilization system: Compared with the traditional method, the waste heat recovery and utilization system can save about 500300 yuan per year and reduce the carbon dioxide emission by 424.1 tons/year.

Renewable energy utilization system： Air source heat pump, solar hot water.

The simulation results show that the energy-saving rate is over 20% and the carbon emission reduction is 3300 tons. The energy-saving effect is remarkable.



	Cooling	Heating	ventilation	water pump	lighting	equipment	total
Design building energy consumption(MWh)	4,682.50	2,040.20	4,292.20	845.40	717.90	1,466.10	14,044.30
Benchmark building energy consumption(MWh)	4,872.02	2,084.39	8,129.17	992.25	854.64	1,511.44	18,443.92

Figure 97: Pre-Evaluation of Energy Saving Effect

Source: CNSC Program Joint Operation Center

The issuance process of green bonds mainly includes five steps: firstly, you need to clarify green assets and projects, for example, renewable energy, public transportation are green assets. Then you have to arrange independent review, Credible independent review and verification can help maintaining credibility. The third-party audit agency can also assist in identifying green assets. The next step is to ensure transparency. The issuer needs to track assets and be able to explain how to track it. After that is the issuance of bonds. The steps of issuing green bonds are the same as those of traditional bonds: at first you need to obtain the license from the regulatory authorities; then determine the bond structure through cooperation with investment banks or investment advisers; the last step is marketing and pricing green bonds. After the bond is issued, you need to confirm that the funds are properly allocated to green projects. This may be done by a person authorized by the company.

How to determine the qualified green asset projects? The key attribute of green bonds is that the funds raised are only used for green projects or assets.

Haitian center project is a LEED gold certified and three-star certified green building, which meets the standards of green industry projects.

Most green bond issuers use third Party audit agency to increase investors' confidence, that the projects supported by green bonds have green qualifications. The owner of the project entrusts an independent review company to provide independent evaluation and certification services before issuance. This certification is to provide a professional assessment, clarify the category of green projects and the environmental benefit of the project, so as to ensure that all the funds raised by the bond are invested in green projects.

Full disclosure of the distribution of raised funds is very necessary. The funds raised by green bonds must only be used for special projects, so we should establish a system so that we can isolate and track the funds. The owner of this project has established a reliable control system and established a special account for the acceptance, storage and use of the funds, to ensure that the funds are earmarked for special purposes. The owner has also improved the relevant disclosure systems.

After completing the above procedures, the green bonds of this project were issued non publicly in the stock exchange: the total issuance amount of green bonds of the project is 2.5 billion yuan, which is divided into two phases to issue. After the issuance of green bonds, regular reports are required to confirm that the project funds are properly used for the implementation of green projects.

By the end of March 2021, the remaining green bond funds of Haitian center project were 76 million yuan, and the cumulative net expenditure of green bond funds was 2.4 billion yuan.

2.4.4. Insurance Linked Securities and Catastrophe Bonds ("Cat Bonds")

Authored by John Zhang, SwissRe

Climate change is considered as a major threat to the resilience of the society. Polar ice shields are melting, and the sea is rising. In some regions extreme weather events and rainfall are becoming more common while others are experiencing more extreme heat waves and droughts. The damage could be very substantial.

The Insurance Linked Securities (ILS) including Catastrophe Bonds (Cat Bonds for short), Sidecars, etc. serve as a bridge linking the capital market to the social resilience. Investors diversify the market risks through introducing Cat Bonds into the investment portfolio due to the strong uncorrelation between Catastrophe/Climate risk and financial risk. Insurers who are the sponsors of Cat bonds, provide Catastrophe covers to help commercial clients and personal customers in the global society fight against the natural hazards. The tail risk of huge climate risk events is considered too big for an individual insurer and in this case, Cat Bonds (or ILS more broadly) transfer the tail risk directly to the capital market that has much bigger capacity than insurance industry. Therefore, Cat Bonds and ILS are an effective way to protect the society from climate risk.

The inborn nature of social resilience and climate risk protection endows Cat Bonds and ILS products with a strong Environmental, Social and Governance (ESG) element, and makes them a more and more popular type of assets in the market with regards to green finance and sustainable investment.

What is Insurance Linked Security?

Natural catastrophe bonds and other types of ILS are usually issued in order to provide re-/insurance protection to insurers, reinsurers, governments, and corporations.

Cat bonds allow companies to obtain reinsurance protection from a new pool of capital separate from traditional reinsurers. Money managers, hedge funds, and pension funds represent a new pool of capital for insurers and reinsurers to gain protection from.

Investor capital sits in a segregated collateral account, meaning that if an event occurs, dedicated funds are available to make a payment. This mechanics virtually eliminates the credit risk inherent in traditional re-/insurance and makes the deal feasible.

How did ILS emerge?

In 1992, Hurricane Andrew made landfall in Florida causing $15.5 billion in insured losses. The resulting shortage of reinsurance capacity prompted reinsurers, banks, and academics to investigate new ways of transferring catastrophe risk outside the traditional reinsurance capital pool.

In 1997, Residential Re, the first catastrophe bond was sold to capital markets investors, protecting USAA against the risk of a major hurricane. Since then, approximately $45 billion of cat bonds have been issued, providing protection to over 70 insurers, reinsurers, governments, and corporations for a multitude of risks.

The ILS universe includes a variety of forms as shown below, of which Cat bonds are a more familiarized product.

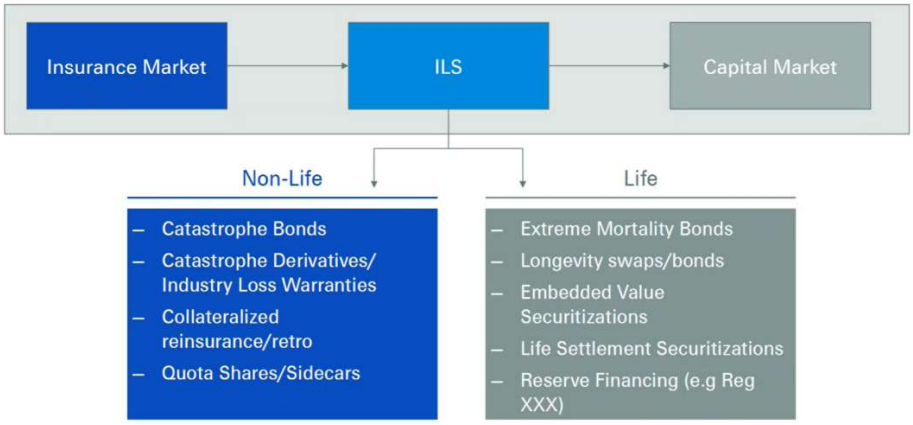


Figure 98: ILS Universe

Source: Swiss Re

How do Cat Bonds Work?

The sponsor (the insurer or reinsurer looking to get protection) enters into a risk transfer contract (reinsurance or derivative) with a special purpose company established specifically for the transaction (SPV).

The SPV capitalizes itself by issuing Notes (the "Cat Bonds") to Investors in the capital markets in an amount equal to the limit of the risk transfer contract.

Proceeds from the securities offering are transferred into a collateral trust account and invested to provide a stable return.

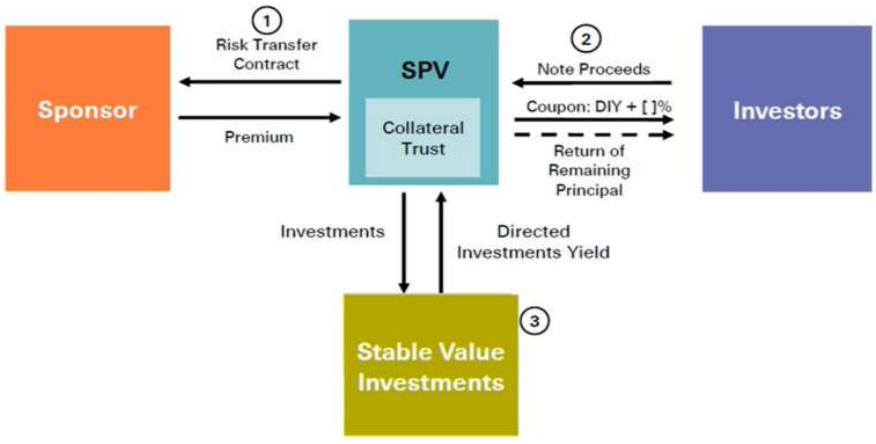


Figure 99: How do Cat Bonds work

Source: Swiss Re

If no covered event occurs during the risk period, the bonds will be redeemed at 100% of face value. In case of a covered event meeting the thresholds set forth in the risk transfer contract, funds will be withdrawn from the collateral account to make an event payment to the sponsor. The redemption price of the bonds is reduced accordingly.

Why Consider Cat Bonds?

From sponsors' perspective, they are concerned about the counterparty credit risk in case of a large event. The shortage of the available traditional capacity on peak perils is another main reason, especially for those insurers with large reinsurance program. The Cat bonds can also diversify the sources of capacity and reduce dependency on just one market. The structural features that the traditional markets have difficulty providing in size at the right price also make them so attractive, e.g., aggregate, second event, drop down cover, etc. A Cat bond always last for 3 to 5 years with stable terms.

From investors' perspective, Cat bonds represent an asset whose value is largely driven by the occurrence of events that are not correlated to the financial markets, allowing for a high degree of diversification. High risk adjusted returns and low volatility present strong attractiveness to big investors when compared to other asset classes. The collateral structure is a third reason. In conclusion, Cat bonds will add to the total resilience of financial market as well as the liability side.

News released in 2021 revealed that the first company destined to be an insurance-linked securities (ILS) special purpose vehicle has already been registered in Hong Kong, China, with Greater Bay Re Limited established to issue a catastrophe bond on behalf of China Re. This is a key breakthrough for Cat bonds in Asia in recent years.

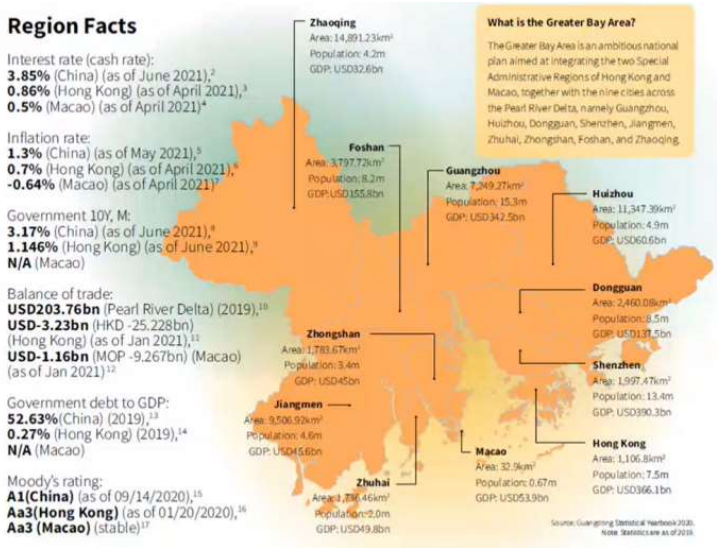


Figure 100: Breakthrough for Cat bonds in Asia

Source: Climate Bonds Initiative

It is an important sign of the state of readiness of Hong Kong, China's legislative and regulatory framework for insurance-linked securities (ILS), showing that Hong Kong, China, is now ready for ILS activity and to become a domicile for catastrophe bonds.

Greater Bay Re Limited was incorporated on 23 June 2022 as a public company in Hong Kong[201]. The name refers to the Greater Bay Area, which represents the Guangdong, Hong Kong, Macau Greater Bay Area. It is now required to be authorised as a special purpose insurance company (SPI) in order to be allowed to engage in ILS business and as a vehicle for issuing catastrophe bonds.

Why ESG investors favour ILS?

As responsible investing continues to gain momentum, the insurance-related securities (ILS) are inclined to playing an increasingly important role[202]. ILS investors are becoming more interested in a broader discussion of ESG products and responsible investing. While sustainability as a topic is growing fast, the market also has to deal with some challenges.

Figure 101: ILS Market Trend

Source: Swiss Re

The environmental, social and governance (ESG) nature of the insurance-linked securities (ILS) market has emerged as a key driver of issuance activity[203]. ILS and Catastrophe bonds are essentially valued as ESG assets because they are instruments that provide post-disaster recovery financing, protect society from the climate change risks, and come from a market with strong established governance[204].

The Lion III Re DAC transaction is the first catastrophe bond embedding green features in accordance with the Generali Green ILS Framework[205], underlining once more the commitment of the Group in promoting green finance solutions: (i) Generali's freed-up capital resulting from this transaction will be allocated to green projects, (ii) the collateral will be invested into highly rated green notes issued by the EBRD, (iii) there will be a dedicated reporting of the allocation of freed-up capital in eligible projects as well as EBRD reporting on its Green Projects Portfolio which will be provided.

It is to be expected that more sponsors will seek to develop their own ways to add more sustainability to Cat bonds, making it a more ESG-friendly investment opportunity, especially given the wave of demand for appropriate investment opportunities in ESG.

Climate change is considered as a major threat to the resilience of the society. Polar ice shields are melting, and the sea is rising. In some regions extreme weather events and rainfall

are becoming more common while others are experiencing more extreme heat waves and droughts. The damage could be very substantial.

The Insurance Linked Securities (ILS) including Catastrophe Bonds (Cat Bonds for short), Sidecars, etc. serve as a bridge linking the capital market to the social resilience. Investors diversify the market risks through introducing Cat Bonds into the investment portfolio due to the strong uncorrelation between Catastrophe/Climate risk and financial risk. Insurers who are the sponsors of Cat bonds, provide Catastrophe covers to help commercial clients and personal customers in the global society fight against the natural hazards. The tail risk of huge climate risk events is considered too big for an individual insurer and in this case, Cat Bonds (or ILS more broadly) transfer the tail risk directly to the capital market that has much bigger capacity than insurance industry. Therefore, Cat Bonds and ILS are an effective way to protect the society from climate risk.

The inborn nature of social resilience and climate risk protection endows Cat Bonds and ILS products with a strong Environmental, Social and Governance (ESG) element, and makes them a more and more popular type of assets in the market with regards to green finance and sustainable investment.

What are Insurance Linked Securities? Natural catastrophe bonds and other types of ILS are usually issued in order to provide re-/insurance protection to insurers, reinsurers, governments, and corporations.

Cat bonds allow companies to obtain reinsurance protection from a new pool of capital separate from traditional reinsurers. Money managers, hedge funds, and pension funds represent a new pool of capital for insurers and reinsurers to gain protection from.

Investor capital sits in a segregated collateral account, meaning that if an event occurs, dedicated funds are available to make a payment. This mechanics virtually eliminates the credit risk inherent in traditional re-/insurance and makes the deal feasible.

How did ILS emerge? In 1992, Hurricane Andrew made landfall in Florida causing $15.5b in insured losses.

The resulting shortage of reinsurance capacity prompted reinsurers, banks, and academics to investigate new ways of transferring catastrophe risk outside the traditional reinsurance capital pool.

In 1997, Residential Re, the first catastrophe bond was sold to capital markets investors, protecting USAA against the risk of a major hurricane.

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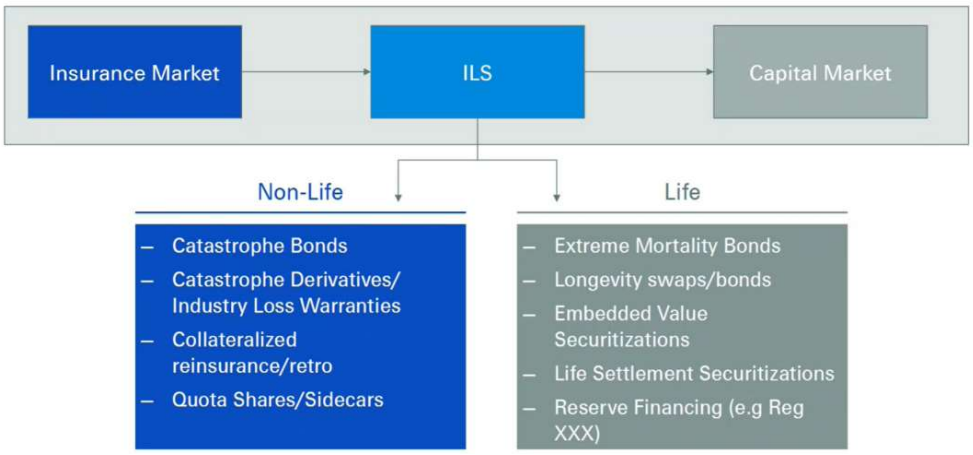

Figure 102: ILS Universe

Source: Swiss Re

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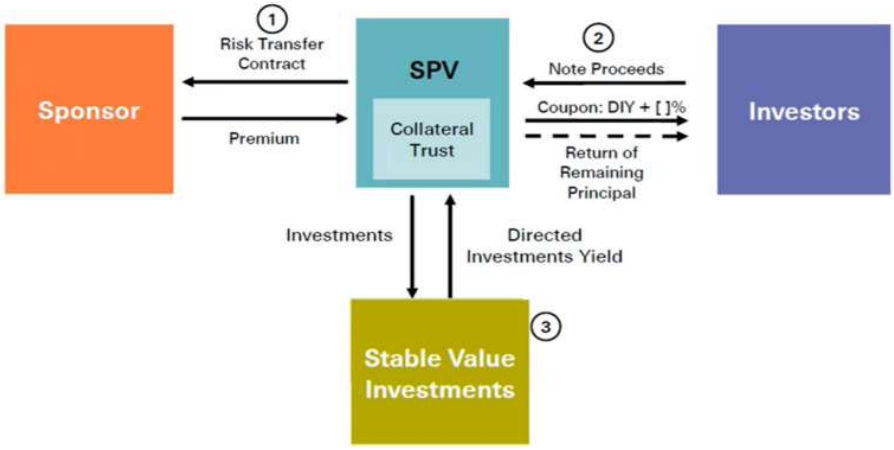

Figure 103: How do Cat Bonds work

Source: Swiss Re

If no covered event occurs during the risk period, the bonds will be redeemed at 100% of face value. In case of a covered event meeting the thresholds set forth in the risk transfer contract, funds will be withdrawn from the collateral account to make an event payment to the sponsor. The redemption price of the bonds is reduced accordingly.

Why Consider Cat Bonds? From sponsors' perspective, they are concerned about the counterparty credit risk in case of a large event. The shortage of the available traditional

capacity on peak perils is another main reason, especially for those insurers with large reinsurance program. The Cat bonds can also diversify the sources of capacity and reduce dependency on just one market. The structural features that the traditional markets have difficulty providing in size at the right price also make them so attractive, e.g., aggregate, second event, drop down cover, etc. A Cat bond always last for 3 to 5 years with stable terms.

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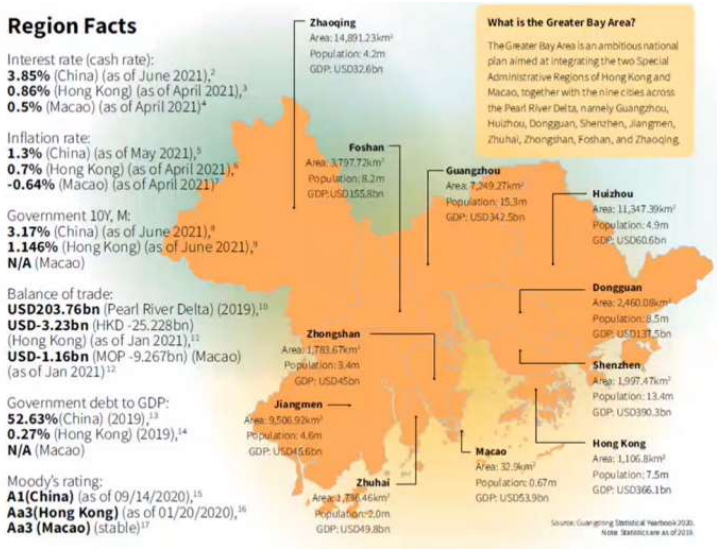

Figure 104: Breakthrough for Cat bonds in Asia

Source: Swiss Re

It's an important sign of the state of readiness of Hong Kong, China's legislative and regulatory framework for insurance-linked securities (ILS), showing that Hong Kong, China, is now ready for ILS activity and to become a domicile for catastrophe bonds.

Greater Bay Re Limited was incorporated on 23 June 2022 as a public company in Hong Kong[206]. The name refers to the Greater Bay Area, which represents the Guangdong, Hong Kong, Macau Greater Bay Area, and is said to be the largest and most populated urban area in the world. It is understood now that one will need to be authorized as a special purpose insurer (SPI), to be allowed to undertake ILS business and act as a vehicle for issuance of a catastrophe bond.

ESG investment in ILS

As responsible and sustainable investing continues to gain traction, the insurance-linked securities (ILS) asset class is expected to play an increasing role[207], but it is important that the

sector tells its own environmental, social and governance (ESG) story. ILS investors are increasingly interested in discussing ESG products and responsible / sustainable investments more broadly. However, when compared with certain other structures available in the investment universe, ILS is somewhat lagging. While stainability as a topic is evolving at a rapid pace, there are challenges that the market must address.

Figure 105: ILS Market Trend

Source: Swiss Re

The environmental, social and governance (ESG) credentials of the insurance-linked securities (ILS) market have become a key driver for issuance activity. ESG has been a particularly hot topic in ILS markets and among investors looking at the range of ILS assets, from catastrophe bonds to collateralized reinsurance, for more than two years now.

ILS and catastrophe bonds are seen as having inherent ESG qualities, given they are vehicles for provision of disaster risk and recovery financing, protect society against environmental impacts of weather and natural disaster events, and come from a marketplace with strong governance already in-place.

While those ESG allocators have huge amounts of capital to deploy, the somewhat limited size of the cat bond market may be particularly affected by attention stimulated by ESG awareness of the asset class.

With very few cat bonds explicitly issued with an ESG report so far, this bodes well for the market as its ESG adoption matures and more information is supplied to managers and investors on the relevant qualities of individual transactions and ILS investment opportunities.

The environmental, social and governance (ESG) credentials of the insurance-linked securities (ILS) market have become a key driver for issuance activity[208].

ESG investing is a growing focus for the insurance-linked securities (ILS) market[209].

Some insurers have welcomed the first green cat bond issuance, the EUR 200 million Lion III Re DAC transaction[210]. The Lion III Re DAC transaction is the first catastrophe bond embedding green features in accordance with the Generali Green ILS Framework, underlining once more the commitment of the Group in promoting green finance solutions: (i) Generali's

freed-up capital resulting from this transaction will be allocated to green projects, (ii) the collateral will be invested into highly rated green notes issued by the EBRD, (iii) there will be a dedicated reporting of the allocation of freed-up capital in eligible projects as well as EBRD reporting on its Green Projects Portfolio which will be provided. In addition, the primary service providers engaged have shown commitment to a sustainability framework in their business activities.

It's encouraging to see these green features added to a cat bond, which could serve to expand the range of investors interested in allocating to insurance-linked securities (ILS), such as catastrophe bonds, especially given the wave of demand for ESG appropriate investment opportunities.

We anticipate other sponsors will look to develop their own methods for adding more sustainability to cat bonds and making them a more ESG friendly investment opportunity.

2.5. The Role of International Financial Institutions

2.5.1. Asian Development Bank ADB

Authored by Yiyang Shen, Inclusive Development Research Centre IDRC

Asia is changing; every economy is trying to promote green development. This includes achievements such as smart city, smart infrastructure and green infrastructure. The Regional Comprehensive Economic Partnership (RCEP) has been signed and entered into force. It is expected that RCEP will have a significant impact on the whole region, not just China and Southeast Asia. Many economies are paying attention to green infrastructure, also known as sustainable infrastructure, including power, water treatment, water supply, roads, railways, etc. The Asia Pacific region will be more closely linked. At the same time, technical standards and green financing will also be unified in the Asia Pacific region. The future will see a stronger trend towards green development.

In rural areas, a lot of progress also took place, in energy due to Sustainable Energy for All, but also in water supply, water treatment and similar areas.

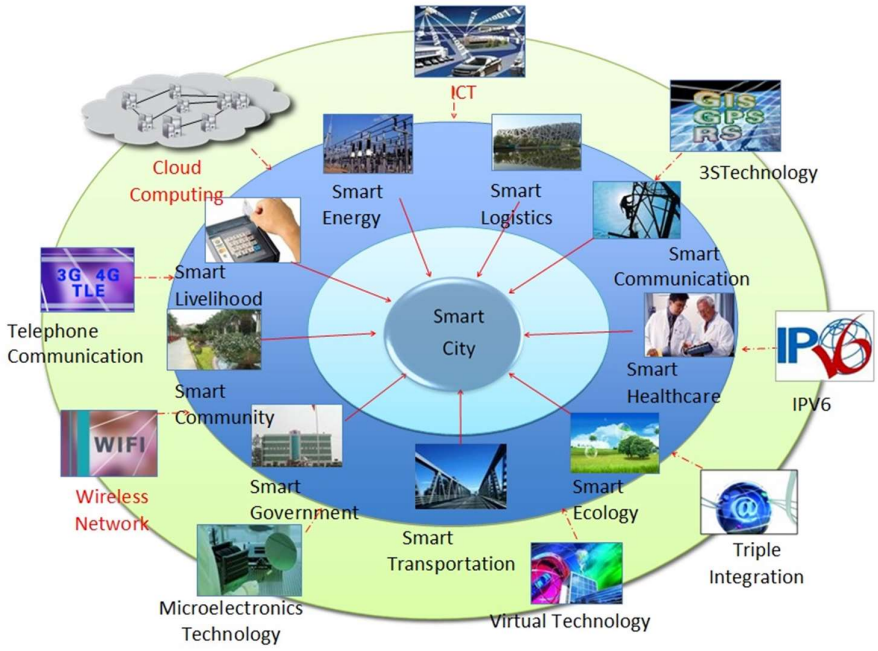

Figure 106: Technical Component Systems of a Smart City

Source: IDRC

The institutional linkages of the Asian Development Bank can be described as follows. Basically, ADB is performing different kinds of support strategies. The largest department is the sovereign long department or sovereign financing department. That means, the member governments will be providing guarantees to ADB, and ADB provides low interest loans to the member economies and projects. Also, ADB has a private sector development department (PSOD). This is providing a more complex investment strategy and can also provide equity investment for developing economies to ensure that the goals can be achieved. For all its stakeholders, ADB has a strongly developed government cooperation including with other commercial banks and the public private sectors. All partners work together towards strong support for the stakeholders.

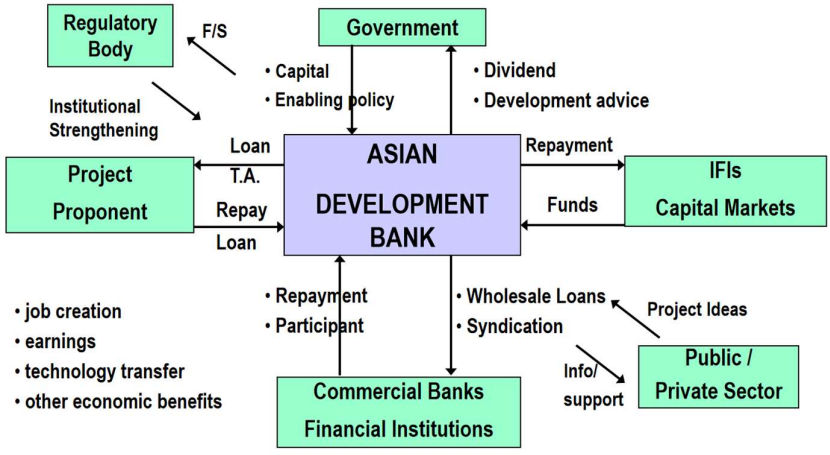

Figure 107: Institutional Linkages of the Asian Development Bank

Source: IDRC

The different roles of a development bank are summarized in the table hereafter. Development banks are initiators (e.g., for providing clean coal technology to Asian partners), institution builders, catalysts, development advocates and can sometimes also be lenders of last resort.

Initiator	Institution-Builder	Catalyst	Development Advocate	Bank of Last Resort
Plays a "supply-leading" role (in anticipation of future demand) e.g., technology transfer, strategic industries, environmental projects	Develops new methodologies & systems in raising capital & increasing investments through non-traditional areas, e.g., financing large projects via BOT, BOL, BOO, etc.; capital market; microfinance	Takes a lead role in creating new financial packages with involvement of banks & other financial institutions, e.g., loan syndication of large projects; guarantee schemes for industry sectors	Promotes the 'business' of development such as job generation, domestic resource mobilization, country-side development, MSMEs	Assists projects that no other financial institution will fund, thus promoting new & innovative economic activities, e.g., funding for inventors, cooperatives and high-risk investments

Table 7: Roles of a Development Bank

Source: IDRC

Technology transfer is very important to drive the world towards sustainable economy and energy patterns. For this reason, the ADB has adopted similar approaches to the World Bank for supporting technology transfer among its stakeholders. In doing so, it has paid attention to use both, a top-down approach as well as a bottom-up approach, in attempting to leapfrog stakeholders.

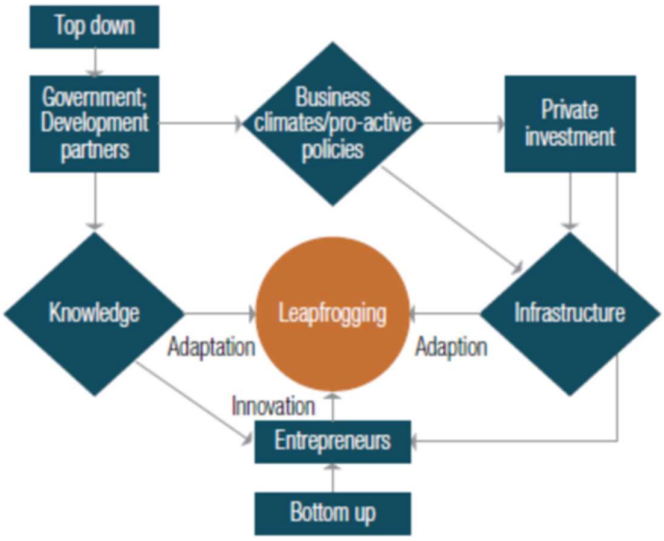

Figure 108: Technology Transfer Route

Source: World Bank

The benefits of green finance are numerous and can be classified in several categories.

The most obvious category of benefits contains the direct financial gains. These comprise cost savings in energy or raw materials (water, paper, etc.). Furthermore, the increased cost-consciousness among employees and the lower future compliance costs can be considered in this category.

A second category of benefits of green finance can be subsumed under the title reputational benefits, comprising not only the possibility to attract and retain customers, but also to maintain the best qualified employees, and a better public image in general.

A third category of benefits of green finance comprise risk reduction and workplace benefits. These refer to the lowering of political, legal or community risks, to less risks from the environment and from accidents.

A fourth category of benefits refers to the environmental and ecological gains of green finance due to the development of clean environmental services and its positive impact on the access of clean resources.

Green finance has also been a driver for ESG (environmental, social and governance) issues. Thereby, green finance acts on tangible value drivers (profitability, asset utilization, service quality), as well as on intangible value drivers (customer relationships, brand, equity and reputation, alliances, technologies). ESG is also sometimes described as Equator Principles.

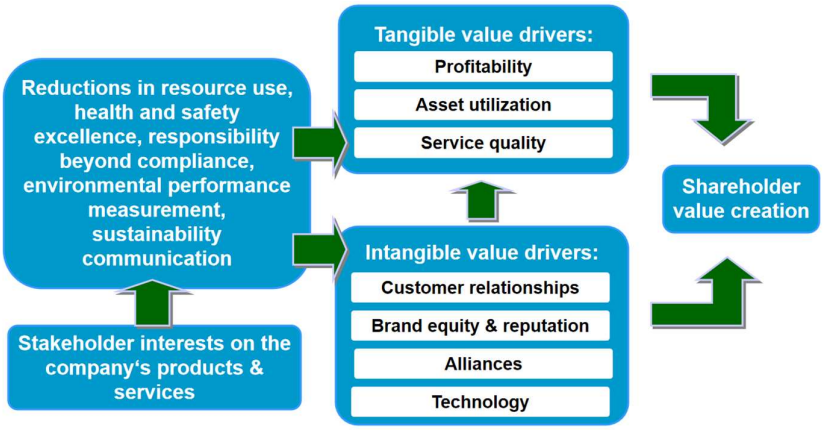

Figure 109: Green finance as ESG driver

Source: IDRC

ADB can showcase many investment projects and is trying to integrate these projects with the domestic energy development strategies. We can find the influence of the membership's development strategy in every ADB invested project. ADB attaches importance to co-financing with other international financial institutions. ADB is also trying to connect different potential opportunities through investment.

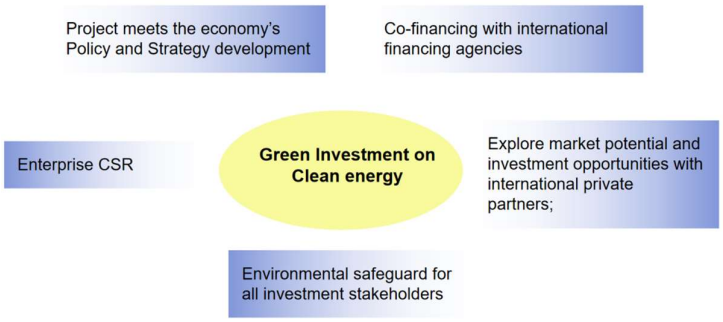

Figure 110: Green Investment Cooperation

Source: IDRC

ADB closely works with other renewable energy and climate financing organizations. Especially for the energy sector and the so-called climate financing sector, many other partners can be also supportive. The different ways in which ADB cooperates comprise technical assistance and grants, equity, mezzanine finance, long term loans, short term loans, or risk management guarantees. With some organizations, cooperation takes place only on one of these items, where others share broader cooperation patterns.

Organization	Technical Assistance /Grant	Equity Capital	Mezzanine	Long term loan	Short term loan	Risk Management /Guarantees
DEG	X	X	X	X		X
FMO Entrepreneurial Bank (IDF and AEF)	X	X	X	X	X	X
KfW & Partners (SA & Tunisia only)				X		
Global Energy Efficiency and Renewable Energy Fund (GEEREF)	X	X				
International Climate Fund (UK)	X			X		X
Global Climate Partnership Fund (SA & Tunisia)	X			X		X
IRENA / Abu Dhabi Fund for Development (ADFD)				X		
(ACAD)	X			X	X	
Climate and Development Knowledge Network	X					
Climate Finance Innovation Facility (CFIF)	X					X
Climate Technology Initiative (CTI) Private Financing Advisory Network (PFAN)	X					X
Norwegian Investment Fund for Developing Countries (Norfund)		X		X		
Interact Climate Change Facility (ICCF)		X				
Energy and Environment Partnership (EEP)	X					
EIB Climate Change Technical Assistance Facility	X			X		
IFC Partial Credit Guarantees				X	X	X
IDB's Infrastructure Fund (InfraFund)	X					
IFC Risk Sharing Facility						X
GAP			X			

Table 8: Supportive Partners

Source: IDRC

One initiative which has also been of some importance to ADB is the Belt and Road Initiative. Sometimes referred to by its older name as "One Belt, One Road" is an extensive, open, transparent, inclusive, diversified and win-win initiative.

Extensive: directly benefiting a population of 4.4 billion people or 63% of the world's population, with a combined GDP of 21 trillion US dollars that accounts for 29% of the world total.

Open, transparent and inclusive: this initiative has so far received active and actual participation by over 70 economies and international organizations.

As to the type of projects, it is highly diversified in terms of its goals or cooperation priorities.

Figure 111: Belt and Road Initiative

Source: IDRC

The Belt and Road Initiative shows opportunities for investor in five key areas. While trade and investment are certainly an important pillar, the initiative also includes building facilities to enable connectivity, financial integration comprising also cooperation in monetary and policy coordination, as well as policy coordination. The cultural exchange that is part of the initiative has been suffered most from the pandemic.

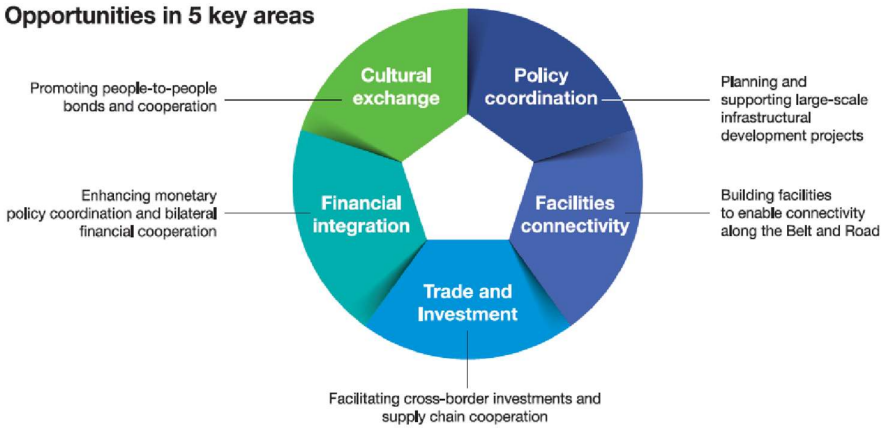

Figure 112: Opportunities of the Belt and Road Initiative

Source: IDRC

The Belt and Road development initiative involves a huge amount of infrastructure projects, creating tremendous business opportunities for international companies. These projects call

for financing and investment-related services. The ensuing increase in cross-border trade, investment and other economic activities calls for increased logistics, maritime, trading services and professional services. ESG and inclusive development need to be promoted.

Africa's apparently unstoppable march to become one of the most popular destinations for investment is now perceived as a more attractive market than other emerging markets. In contrast to other more developed markets, the major driver of the expected performance is the underlying growth in earnings and the implicit underlying economic growth. In line with the current limited use of leverage in African private equity, limited partners (LPs) do not expect leverage to play a significant role in the return on capital achieved. This lack of leverage may contribute to lowering the perceived risk of private equity in Africa.

Figure 113: Belt and Road Investment Opportunities

Source: IDRC

2.5.2. Asian Infrastructure Investment Bank AIIB

Authored by Ping Yean Cheah, AIIB

Launched in Jan 2016, the AIIB is a multilateral development bank (MDB) that is focused on infrastructure investment in Asia with the end-goals of fostering sustainable economic development, creating wealth and improving connectivity. It currently has 104 members, including non Asian members. As of Q1 2022, it invested in 168 projects with an approved amount totalling USD 33 billion.

AIIB's investments are driven by the broadly defined mandate stated in its Articles of Agreement, an inaugural Corporate Strategy 2030 and sectoral strategies. The strategy documents of AIIB provides the framework, principles and operational modalities to guide its sectoral engagements including development of its project pipeline and business lines. One of its core focus sectors is energy.

Launched in 2017, AIIB's Sustainable Energy Strategy outlines the following six guiding principles:

a. Promote energy access and security
b. Realise energy efficiency potential
c. Reduce the carbon intensity of energy supply
d. Manage local and regional pollution

e. Catalyse private investments; and
f. Promote regional co-operation and connectivity.

AIIB's direct energy sector investments amounted to over USD 5 billion over the period 2016 – 2021, representing 34% of AIIB's total regular financing amount. It is the largest vertical infrastructure sector by investment volume. AIIB's approved energy portfolio covers conventional electricity generation, transmission and distribution and various types of renewables, including hydropower. AIIB also invested in financial intermediaries and platforms that would on-lend to entities that develop or operate renewable energy and energy efficient infrastructure.

This sectoral strategy is complemented by AIIB's Sustainable Cities Strategy that was launched at the end of 2018. The latter is treated as a cross-sectoral initiative, with the urban setting as a testbed for integrated and sustainable infrastructure development. Urban energy transition has been identified as an investment focus area.

AIIB's urban strategy is also in sync with UN-Habitat's recognition that cities are the enablers and barriers for respective economies to reach their Nationally Determined Contributions (NDCs) under the Paris Agreement 2015.

Guided by its Strategy 2030, Sustainable Energy and Sustainable Cities Strategies, AIIB has set a 50% target of climate financing against its total approved portfolio by 2025 and an earlier deadline of 1 July 2023 for its operations to be aligned with the goals of Paris Agreement. These targets mark a key milestone in the Bank's commitment to go "green".

The urban energy transition provides multiple windows for AIIB to support climate action in its operations and may manifest in the following scenarios:

a. Enhance existing partnerships with international financial institutions (IFIs), bilateral agencies, private financiers and standard setting agencies to co-prepare and co-finance infrastructure projects
b. Convene various stakeholders (which is exceptionally challenging in an urban project) to foster collaboration, particularly in preparing urban infrastructure projects to bankability level
c. Work with donors and funds to promote blended financing instruments
d. As part of project preparation, promote awareness and obtain "buy in" from local communities to incorporate climate resilient components in urban infrastructure projects; and
e. Adopt digital technology for monitoring, reporting and validation (MRV)

2.5.3. Green Climate Fund GCF

Authored by Drazen Kucan, GCF

The IEA estimates that cities cause at present 71% of greenhouse gas emissions, a percentage that is expected to rise to 76% by 2030 with the increasing urbanization taking place if all three emission scopes are counted. Recall that scope 1 stands for production-based emissions happening within the boundaries of the city, scope 2 for consumption-based emissions associated with grid supplied electricity, and scope 3 for consumption-based emissions embodied in goods that are consumed within the city (building materials, products of energy-intensive industries, water, etc.).

The variability among cities is considerable. The average per capita GHG emissions of some selected cities is shown hereafter. Per capita emissions of Rotterdam are almost 250 times as high as in Kathmandu. The per capita GHG emissions also depend closely on the development level, urban form, service access and other factors.

City	Per capita GHG emission
Rotterdam	29.8 t CO_2eq.
Sydney	15 t CO_2eq.
Shanghai	12t CO_2eq.
Mexico City	4.25 t CO_2eq.
Amman	3.4 t CO_2eq.
Colombo	1.54 t CO_2eq.
Kathmandu	0.12 t CO_2eq

Table 9: Per capita GHG emissions

Source: GCF

The rationale for climate change transformative urban investment is based on the UNFCCC Technical Paper 13 (2014)[211]. It refers to integrated, cross-sectoral mitigation activities in urban areas, that illustrates the transformational impact:

"… *through strong mitigation actions aimed at low-carbon, climate-resilient development at the local level across the key sectors such as buildings, transport and waste, …cities in aggregate could reduce their GHG emissions in these core sectors by an estimated 24 per cent by 2030 and by 47 per cent by 2050 (Erickson et al., 2014)*[212]".

To undertake its core mandate to foster paradigm shifts and transformation addressing climate change, the GCF needs a) to find ways to influence and b) where possible fundamentally alter the form and functioning of urban systems, which currently perpetuate resource-intensive and high-carbon process. Below is what we want to avoid.

Figure 114: Slums in Manila

Source: GCF

Transformative action fields in cities are broadly recognized to be the following, see first column of the table below. The second and third column give the benchmarking indication as to how much GHG reduction each field of action is expected to contribute by 2030 and 2050 respectively.

Transformative Action Fields	2030 GHG emissions reduction	2050 GHG emissions reduction
Decarbonization of energy sector: renewable energy and storage	50% to 70% renewables, saving 35% - 45% of GHG At cost $40-$80 per MW	Up to 90% reduction based on the same trend
Improving energy efficiency in building stock	Buildings: 32% reduction in primary material consumption and associated GHG	Buildings: 53% reduction in primary material consumption and associated GHG
Mobility and transport	20% to 45% emissions reduction	Same trend
Urban form	20% emissions reduction	40% emission reduction combined with transportation strategies
Urban resilience	DRR / Optimizing value for money through resilience enablers	DRR / Optimizing value for money through resilience enablers
Materials and material flow	32% reduction in primary material consumption and associated GHG	53% reduction in primary material consumption and associated GHG
Improving waste management	20 % reduction in related GHG emission	40% reduction in related GHG emissions

Table 10: Transformative Action Fields for Cities

Source: GCF

The GCF has identified four different drivers that act on the transformative action fields, see the columns of the table hereafter.

Drivers of change across the GCF results area		Four drivers of paradigm-shift			
		Transformational planning & programming	Catalyzing climate Innovation	Mobilization of finance at scale	Expansion and replication of knowledge
Paradigm - shift pathways (Transformative Action Fields)	Decarbonized & distributed Energy	▪Strengthen mechanisms to implement NDCs and urban climate targets through planning and programming process ▪Foster integrated urban, transport, energy and infrastructure development ▪Institutional strengthening for pipelining and project development ▪ Develop and apply new technical standards (MES etc.) and performance standards in support of the above	▪New business models that reduce upfront capital cost requirements and tap new revenue sources (ex: pay-as-you-go schemes; land value capture, etc.) ▪Support to integrated implementation of new technologies ▪New institutions (ESCOs, etc.) ▪New urban development models (TOD, etc.) ▪New legislation (producer responsibility)	Increased access to of cities and city institutions to domestic and international capital markets through ▪Support to pipeline development at scale ▪Catalyse and participate in private sector funding vehicles e.g., SPVs for PPPs ▪Targeted investments in catalytic funds, city raisings and PPP structures ▪Support to direct access AEs (especially NDBs) in subnational climate financing ▪Mechanisms to enhance the use of blended finance, sub-sovereign finance and mechanisms to leverage the private sector to work for cities – especially in SIDS and LDCs ▪Mobilization of national and global PIC funds through capital markets ▪Incentivize IFIs to leverage resources and to incentivize efficiency and innovation	▪Developing knowledge products on business models through the Community of Practice for each TAF ▪Utilise partnerships within CCFLA to upscale action on project development, PIC financing and NDBs ▪Partner with other agencies & networks to maximize knowledge feedback / learning loops in each TAF sector ▪Effectively disseminate knowledge through GCF knowledge repository and networking events
	Energy efficient buildings				
	Green & mobility-enhanced cities				
	Circular urban economy				
	Compact & resilient urban form				

Table 11: Four drivers of paradigm-shift

Source: GCF

GCF diagnoses urban climate financing recalibration, which means looking at the relationship between local and central government level, how the transfer of resources from the central to the local government is organized, what the centralization and decentralization pressures are, how the opportunities and threats between the local and the central level interact. The central level acts on top-down approaches shown on the left, whereas the local level acts on bottom-up approaches shown on the right in the figure below.

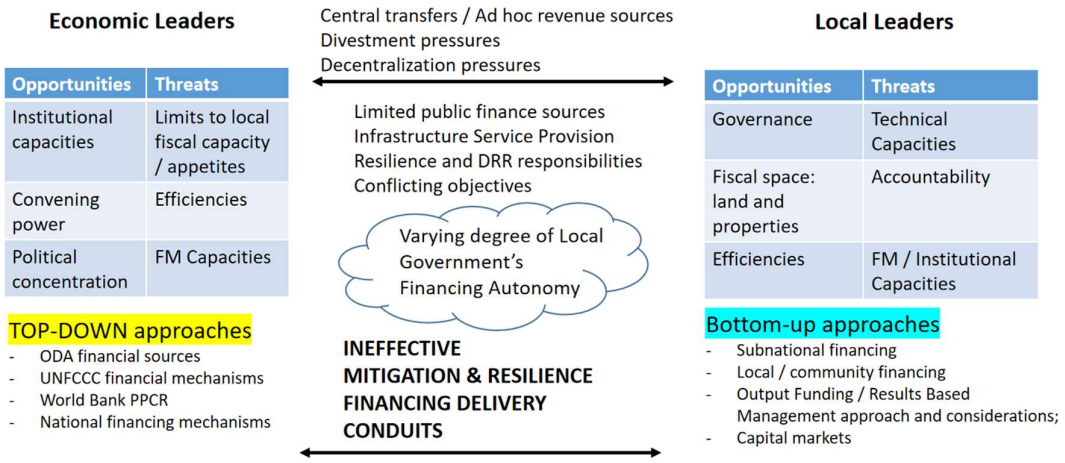

Figure 115: Diagnostics – urgent need for urban climate financing recalibration at global scale

Source: GCF

The above situation could be improved in a forward-thinking approach to climate finance for cities. We can distinguish between demand side measures and supply side measures. It is also important that these are properly sequenced.

Demand side measures comprise:

- Capacity for structuring hybrid / catalysing financing solutions – knowledge transfer and policy support
- Project development vehicles
- Greening of existing public finance flows
- Private participation in financing
- Legal and regulatory framework, including arbitration mechanism
- Enhancing creditworthiness, boosting utilities credit rating and municipal revenue autonomy, fiscal and administrative capacities
- On a long run, strengthen domestic capital markets

Supply side measures are:

- Facilitative financing mechanisms (municipal development funds)
- Incentive structures (risk mitigation and credit enhancement)
- Specialized financial instruments and mechanisms (pooled finance, insurance, revolving funds, municipal bonds, guarantees, viability gap subsidies and funding, etc.)
- Public money as a 'seed' source (guarantees, insurance, incentives, knowledge and policy support, preparatory technical assistance, etc.) to attract and mobilize private finance with staying power through de-risking structures and transformative interventions

The GCF invests through four different basic instruments. 1) Grants may be given without obligation of repayment. 2) Equity may include both, ordinary and junior equity, 3) Guarantees are instruments similar to insurances that may or may not materialize in payments from GCF, depending on the situation, and 4) concessional loans, also in both, senior and subordinated forms, are loans at preferential conditions.

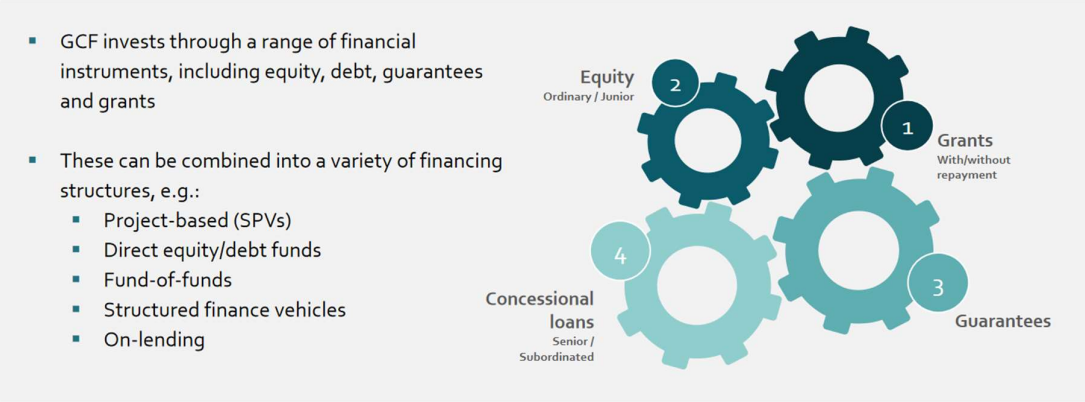

Figure 116: The range of GCF financial instruments

Source: GCF

Concerning the grants and the concessional loans, some more information can be given. Grants are available in major convertible currencies, with or without repayment contingencies (no reimbursement required), or grants with repayment contingency where the terms are adapted to the required level of Concessionality of the project or programme.

The conditions of concessional loans are shown in the table hereafter. The maturity varies between 20 and 40 years, with a grace period between 5 and 10 years, annual principal repayment depending on the period, interests between zero and 0.75%, low service fees and commitment fees per annum.

Type of Concessional Loans	Major Convertible Currency	Maturity (years)	Grace period (years)	Annual principal repayment Years 11-20 or 6-20 (% of initial principal)	Annual principal repayment Years 21-40 (% of initial principal)	Interest	Service fee per annum	Commitment fee per annum
High	Any	40	10	2%	4%	0.00%	0.25%	Up to 50 bps
Low	Any	20	5	6.7%	NA	0.75%	0.50%	Up to 75 bps

Table 12: Financial terms and conditions of concessional loans

Source: GCF

The role of the Green Climate Fund is above all in de-risking investments and in concessionality. De-risking of investments means reducing risk in a transaction, representing an anchoring role for co-investors to participate, fostering behavioural changes conducive to climate impacts, and creating demand by making climate solutions affordable.

The instruments of concessionality includes pricing, mapping out the subordinate positions, setting flexible terms and tenors, flexible guarantees and making fit for purpose grants to foster climate action.

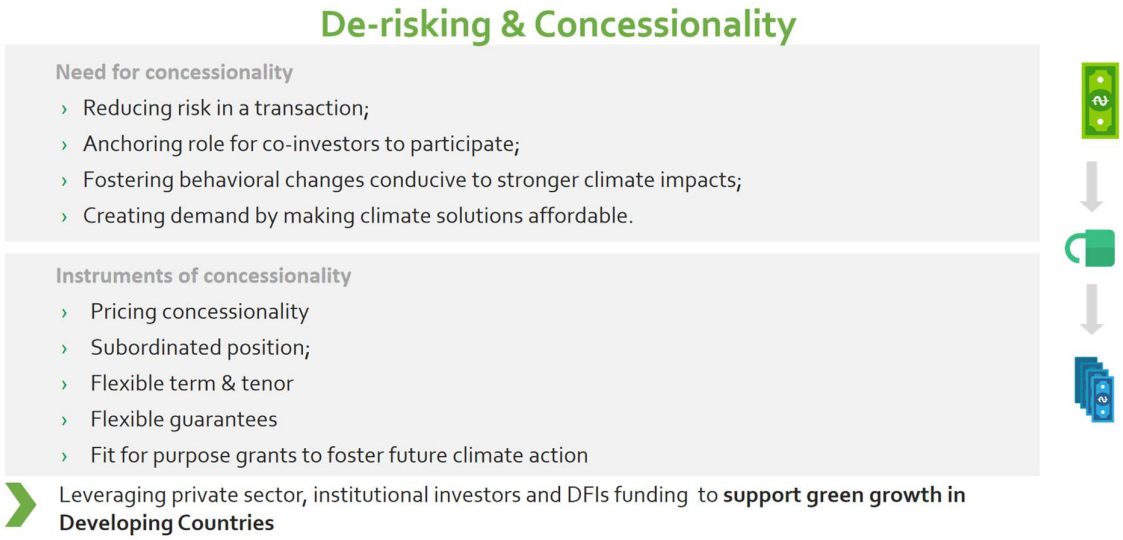

Figure 117: Role of the Green Climate Fund in de-risking and concessionality

Source: GCF

The GCF is the financing organization of the Paris Climate Agreement. Projects funded by GCF should, therefore, have a strong climate rationale and some funding from other organizations, making GCF funding be additional. Projects should align with NDCs and not face any serious objections. The 8 priority areas of funding are energy, transport, buildings/cities/industries, ecosystems, livelihoods of people and communities, health/food/water, forests/land use, and infrastructure. Currently the GCF portfolio amounts to around $11 billion, of which $3 billion are for cities.

Figure 118: Projects GCF is looking for

Source: GCF

It is important to address market failures and negative externalities. Human settlements are vulnerable to the increasing impacts of climate change such as extreme temperatures and sea level rise, especially in the absence of resilient infrastructure and planning. These trends are expected to grow unless actions are taken to ensure that cities and urban areas are designed to enhance productivity, resilience, and innovation, while reducing the carbon intensity of their economic and social activities. Such efforts will not only generate economic benefits, but also

address market failures such as urban sprawl, congestion, and negative externalities of pollution and carbon emissions.

Either there are megacities that have to be retrofitted with low emissions solutions, or there are secondary or intermediary cities where transformative urban planning has to be immediately applied to decouple economic growth from emissions.

Green Climate Fund's continuous focus of strategic considerations in the urban sector means focusing on green and smart cities, pursuing transformative pathways in urban systems, retrofitting megacities, supporting carbon neutral / carbon negative planning, orientation and development of secondary and intermediate cities; and using catalytic and innovative finance.

GCF calculated that compact, connected, and coordinated cities could deliver up to 3.7 Gt CO_2e/year of savings over the next 15 years and reduce infrastructure capital requirements by over US$3 trillion. GCF cannot do this on its own, but it can be a thought leader and offer financing opportunities for urban projects which can de-risk investments and attract private investors. GCF can support a range of finance mechanisms that will leverage institutional change and linkages.

The table below shows a selection of the GCF Portfolio in cities in the urban and energy efficiency sector.

Title, Country and AE	Total Financing	GCF financing
ADB Ulaanbaatar Green Affordable Housing and Resilient Urban Renewal Project (AHURP) Mongolia	$544 million	$95 million concessional loan $50 million grant
ADB ASEAN Catalytic Green Finance Facility (multi country: Cambodia, Indonesia, Lao PDR, Malaysia, Thailand and the Philippines)	$3.385 billion	$ 280 million concessional loan $20 million grant
World Bank Viet Nam: Scaling Up Energy Efficiency for Industrial Enterprises in Viet Nam	$ 497 million	$75 million guarantee facility $11.3 mil grant
ADB Catalyzing Climate Finance (Shandong Green Development Fund) PRC	$ 1.5 billion	$100 million concessional loan
UNDP Scaling-up Investment in Low-Carbon Public Buildings, Bosnia-Herzegovina	$122 million	$17.3 million grant
EBRD Green Cities Facility (multi-country: Albania, Armenia, Georgia, Jordan, Moldova, Mongolia, North Macedonia, Serbia, Tunisia)	Euro 600 million	Euro 65 million concessional loan; Euro 22 million grant

Table 13: Selected GCF portfolio in cities in the urban and energy efficiency sector

Source: GCF

As an example of a large-scale project catalysing climate finance, take the Shandong Green Development Fund (SGDF). This project is part of the Beijing – Tianjin – Hebei area. This area has a population of 100 million and 3000 kilometres of coastline. It is representative of the People's Republic of China PRC, with characteristics of high industrialization, and still being the largest energy and coal (10%) consuming region of China. Proactive provincial climate change policies have already been undertaken to decarbonize the economy and promote industrial transformation. As a result, CO_2 emissions will peak by 2027 (3 years ahead of NDC).

The GCF started generating a pipeline of bankable climate positive subprojects according to the above-mentioned six investment criteria. Three batches of projects are transformational (H2, green corridor, circular economy), have advanced benefits (biomass, renewable energy,

green procurement), and good practices (climate-positive sub-projects in line with the government regulation).

GCF is moving from business as usual to good practices, advanced benefits and transformational climate-positive sub-projects based on GCF international climate standards.

The selection of sub-projects is based on the maximization of climate mitigation/adaptation benefits, and improved bankability. GCF is looking at the necessary critical mass of catalytic funding for leveraging Private International Commercial (PIC) investors (>5). Through catalytic funding as applied in this case, involving a catalytic factor of eight, $1.5 billion public funds will leverage $12 billion private funds. This shows how leveraging of private funds allows the Shandong Fund to enter sectors with low interest from PIC investors and can, therefore, be used to finance infrastructures that usually do not attract sufficient private funds, such as sponge cities, sanitation and circular economy. The Shandong Fund is targeted (i.e., climate related), time-bound (with GCF involvement during 5 to 10 years) and transitional (refinancing by PIC investors after the 5 to 10 years period).

2.5.4. International Finance Corporation IFC

The International Finance Corporation IFC is the World Bank's private sector support organization. Contrary to the World Bank who has governments as borrowers, the IFC lends to private enterprises. The IFC is today the largest provider of green loans. Green loans have been briefly presented in section 2.3.2.

In 2020 an innovation was introduced to IFC green loans in that adaptation has been added as a new major component which has immediately jumped to 11% of the volume in fiscal year 2020. Besides this, renewable energy (58%), energy efficiency (13%) and other mitigation (17%) complete the portfolio of green loans.

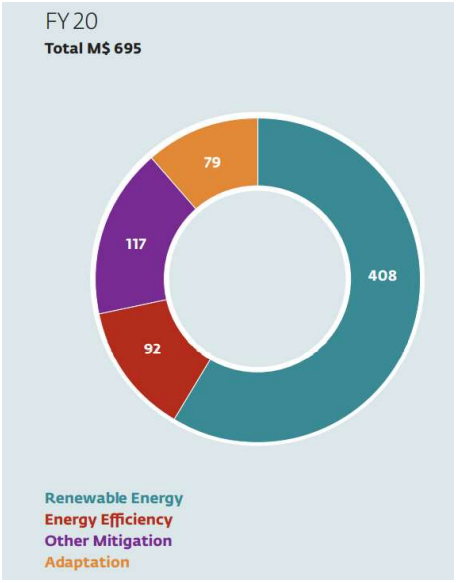

Figure 119: Green loans of the IFC, fiscal year 2020

Source: IFC

As an example of a loan to an APEC economy, the project IEnova (Mexico) can be mentioned, where the IFC has provided a green loan in 2019/2020. In Mexico, IFC structured and mobilized a $541 million 15-year Green Loan facility to support Infraestructura Energetica Nova (IEnova). The green loan will finance the construction of five solar plant projects in Mexico with a total installed capacity of 526 MW. These solar projects will displace carbon-intensive thermal generation and eliminate approximately 793,000 t CO_2eq per year. By financing IEnova's first solar power generation projects, IFC is seeking to support IEnova's transition towards a greener business model. Following IEnova's adoption of the Green Loan Principles, this investment became the first certified IFC Green Loan in Mexico.

Figure 120: IEnova (Mexico): $541 million

Source: IFC[213]

IFC has also provided green loans to China in recent years. The portfolio includes not only solar energy, but also green banking as well as agri-business and forestry. This may illustrate how green loans can be used in practice. The IFC makes reference to sustainable development goals for its projects.

Green bond climate sector	Project short name	Project ID	Economy	Type	Project description	Climate loan committed USD millions	Anual energy produced MWh	Annual Energy Savings kWh	RE capacity constructed/ rehabilitated MW	Green building impact M2	Other impact	Expected annual reduction in GHG emission tCO2eq/ year	Sustainable development goals
Solar	Linyang En	41370	China	RE	IFC's loan will finance the construction of the first grid-parity* solar projects in China which will help to reduce GHG emissions and meet increased electricity demand	11	368,456	N/A	299	N/A	-	273,989	SDG7 SDG8 SDG13
Green banking	Lionbridge Green	41378	China	Other mitigation	IFC's loan will finance expansion of leasing finance services for electric vehicles to truck drivers. This will enable the reduction of GHG emissions through the promotion of leasing finance for environmentally friendly electric trucks.	20	N/A	N/A	N/A	N/A	-	122,419	SDG8 SDG9 SDG12 SDG13
Agri business and forestry	Alpha Fee	41835	China	Adaptation	IFC's loan will finance the aquaculture industry upgrades through the expansion of the extrusion technology-based aquafeed capacity in response to the increasing risk of eutrophication** due to higher water temperatures. This alternative process for aquaculture feed production will increase digestibility and functional properties of the aquaculture	7	N/A	N/A	N/A	N/A	N/A	-	SDG8 SDG14 SDG15

Figure 121: IFC 2020 Loans to projects in China

Source: IFC[214]

3. How Cities Catalyse the Energy Transition

The example of Metro Manila of the Philippines is ranked 7th among the vulnerable urban areas to climate change. A severe problem is the water management during the monsoon months, when around 80% of annual rainfall occurs. The pumping infrastructure is old and not capable to withstand the requirements of recent rainfalls. The entire region is vulnerable to flooding with the coastal areas of Metro Manila registering the highest vulnerability. Metro Manila Flood Management Project is designed to resolve the problems caused by foods. It comprises modernization of pumping stations and drainage areas, minimizing solid waste in the waterways, participatory housing and resettlement, and project management and coordination. The first certified climate bond has been issued in the Philippines in 2016 for a geothermal power station. Today, the Philippines is the third largest green bond issuer in ASEAN. China has made important steps towards the reconversion of industrial parks to Eco-Industrial Parks (EIP). In 2021, UNIDO, World Bank and GIZ have released a set of standardised approaches for implementation of EIP. Focus should be on clean energy, wastewater treatment and waste heat. Asian Development Bank invested in its first eco-industrial park (EIP) waste-to-energy project in Shanghai via a $100 million loan. Another project is the Wuzhou Circular Economy Industrial Park located in Longxu, Wuzhou city, Guangxi Zhuang region. In 2020, the World Bank approved an investment of $200 million for the Jiangxi Eco-Industrial Park. The World Bank is also providing support to the Fuzhou New Industrial Zone, which will provide co-benefits in terms of GHG emission, pollution and urban flood risk reduction. The problems of a medium-size town are illustrated by Tomohon city, Indonesia. The focus lies on developing mass transportation systems to decrease road congestions. An example of a catalytic effect related to urban energy transition is given by Shanghai. A study shows that an energy efficiency and emissions reduction fund plays a catalytic role in enabling coordination and collaboration across different government departments on cross-cutting policy domains.

Looking at the different roles of cities to facilitate the energy transition, the role of policy maker and regulator is essential. Since the adoption of Local Agenda 21 in Rio in 1992, cities have been the focus for shaping and implementing sustainability. The Global Climate Alliance is now the forum where more than 11’000 cities and other stakeholders communicate their policies and exchange experience. In the past years some cities have started adding carbon neutrality as a special objective. 13 APEC cities have become members of the Carbon Neutral Cities Alliance (CNCA). In the role of land planners, cities can inspire themselves from the Five Principles of Sustainable Neighbourhood Planning adopted in 2015 by UNHABITAT concretizing key indicators for transit-oriented development (TOD). Waste management and wastewater treatment give energetic by-products which cities can use. An important role of cities is the one as infrastructure managers. The modern list of infrastructures includes several protective natural infrastructures. PPP can generate green finance. Cities are procurers and consumers, and as such are key players to drive the technologies used to produce energy. Cities are also data producers and should collect data for SDG implementation. But energy and climate data at local level are still rare.

3.1. Best Practice Examples of APEC Cities

3.1.1. City of an APEC Developing Economy – Manila

Authored by Shiela Gail Satura-Quingco, Metropolitan Development Authority, Manila

The Philippines is considered one of the most disaster-prone economies in the world. Its location makes it vulnerable to a variety of natural disasters. Lying on the western rim of the pacific and along the circum-pacific seismic belt, it is subject to storms, typhoons, earthquakes, floods, volcanic eruptions, droughts and faces other natural hazards.

Being an archipelago, the Philippines is also particularly vulnerable to climate change. The melting of glaciers and ice sheets in the North and South poles causes sea level to dramatically rise resulting in coastal erosion, intrusion of seawater, flooding and submergence of small islands especially during high tide.

Metro Manila is one of the fastest urbanizing metropolises in Asia landing 14th among the world's largest cities and urban areas and 18th among the world's largest metropolitan areas, which generally includes an urban area and its surrounding suburbs

It is an agglomeration of 16 cities and one municipality. Metro Manila is a special development region which houses the economic growth centre and central administration of the Philippines. It accounts to more than 1/3 of the total gross domestic product of the Philippines, being the prime region, the centre of commerce, finance and business.

Metro Manila is home to around 12.9 million population based on the 2015 household survey which balloons to more than 15 million during daytime due to the influx of workers and students from neighbouring provinces. It is the smallest region with a land area of only 636 square kilometres occupying less than 1 percent (0.19 %) of the total land area of the Philippines of 343,282.00 square kilometres.

Rapid urbanization coupled with increasing urban population not only puts too much pressure on the land use and physical resources but also competes with the basic services available in the region.

With regards to its vulnerability, Metro Manila was ranked as the seventh "most vulnerable" to climate change among provinces and districts in Southeast Asia. The study entitled 'Climate Change Vulnerability Mapping for Southeast Asia' assessed the vulnerability of 530 urban centres/regional areas in seven (7) Southeast Asian economies, namely Indonesia, Thailand Cambodia, Laos, Malaysia, Viet Nam and the Philippines. Based on the study, Metro Manila ranked 7th among the vulnerable urban areas to climate change. Indonesian cities dominated the list with seven of the top 10.

A majority of provinces or areas in the study's 10 most vulnerable to climate change are found in Indonesia, with Central Jakarta ranked as 1st; North Jakarta, 2nd; West Jakarta, 3rd; East Jakarta, 5th; South Jakarta, 8th; Kota Bandung, 9th; and Kota Surabaya, 10th. Mondol Kiri and Ratanakiri in Cambodia were ranked 4th and 6th, respectively, while Metro Manila in the Philippines was ranked 7th.

The study also includes a map that shows climate hot spots in Southeast Asia. In the Philippines, the following 13 provinces has been identified as "climate hot spots": Cordillera

Administrative Region (27th); Central Luzon (30th); Cagayan Valley (34th); Bicol (36th); Ilocos (40th); Southern Tagalog (44th); Eastern Visayas (60th); Northern Mindanao (74th); Central Visayas (86th); Western Mindanao (87th); Western Visayas (96th); Southern Mindanao (103rd); and Central Mindanao (105th).

Intensive rainfall in the Philippines is especially severe during the typhoon season from June through October when typically, around 80 percent of the annual rainfall falls, which for Metro Manila is about 1,700 mm out of the approximate 2,100 mm average annual rainfall.

Flooding of urban areas is a recurrent problem in Metro Manila that affects traffic and causes flooding in houses and buildings. Urban drainage relies mostly on a combination of drainage channels, waterways, and pumping stations. The Flood Control and Sewerage Management Office of MMDA is responsible for managing the agency's flood management programs and infrastructure. In 2014, MMDA only operates 57 pumping stations. These pumping stations service around 8,000 hectares with a population of over 2.2 million people.

Many of the pumping stations and appurtenant infrastructure were constructed several decades ago and are not functioning anymore up to design capacity for lack of maintenance, solid waste obstructions in channels and waterways, old and inefficient pumping stations, and informal settler families (ISF) obstructing the flow of waterways and drainage channels. As a result of all this, pumping stations perform poorly, resulting in drainage problems even during moderate rainfall events, while the drainage water recedes slowly, impacting the living conditions of many people. Urban drainage improvements within Metro Manila are considered by the Government of the Philippines (GoP) a priority to lessen the impact of rainfall events on people and the economy. Improvements will require a multi-sector approach of simultaneously improving physical infrastructure, solid waste management, and addressing the issue of ISFs living near waterways and drainage channels.

Metro Manila has grown rapidly during the past decades and in many areas flood waters cannot be discharged for lack of pumping stations. MMDA and several Local Government Units (LGU) have constructed small pumping stations during the past years, but there is a need to construct a number of large pumping stations to serve more recent urban developments in a substantial way.

Flooding situation in Metro Manila, especially in low-lying areas, is caused by high intensity or long duration rainfall or storm waters which result to surface run-off and overflowing of rivers primarily became our existing system of 'esteros' and modified natural channels and canals are inadequate.

The capacity existing drainage system of Metro Manila which were mostly constructed in the 1930's and designed to accommodate the level of development requirements then is insufficient and contributes significantly to making the entire region very vulnerable to flooding.

Other major contributory factors aggravating flooding are the obstruction and constrictions of the waterways brought about by the proliferation of informal settlements, illegal structures, and indiscriminate dumping of garbage.

Based on the Flood and Landslide Susceptibility Map of Metro Manila produced by the Mines and Geosciences Bureau of the Department of Natural Resources (DENR), the entire region is vulnerable to flooding with the coastal areas of Metro Manila registering the highest vulnerability.

The Metro Manila Flood Management Project (Phase 1)

In order to address the perennial flooding of the region, and thereby reduce the vulnerability as well as strengthen the resilience against floods, the Metro Manila Flood Management Project (Phase 1) was launched between the Metropolitan Manila Development Authority (MMDA) and the Department of Public Works and Highways (DPWH). The project was funded by the World Bank and Asian Infrastructure Investment Bank (AIIB). The project will be implemented from 2018 up to 2024.

Figure 122: Metro Manila Flood Management Project (Phase 1)

Source: MMDA Metro Manila Flood Management Project

The Metro Manila Flood Management Project is Phase 1 of the implementation of the Metro Manila Flood Management Master Plan which was approved by the Philippine government in 2012. The Master plan aims to reduce vulnerability and strengthen resilience against floods.

It specifically addresses the structural measures to improve urban drainage in Metro Manila. It will be achieved through an integrated set of interventions to modernize existing pumping stations and make improvements to appurtenant infrastructure; construct new pumping stations to accommodate urban expansion; increase short-term water retention capacity in the drainage areas; reduce the volume of indiscriminately dumped solid waste into waterways, and support community-driven resettlement of Informal Settler Families (ISF) encroaching in easements for drains and waterways linked to the project pumping stations to safer in-city locations.

MMDA is in-charge of the implementation of the Metro Manila Flood Management Project's Component 4, Project Management, Support and Coordination, and Component 2 or Minimizing Solid Waste in Waterways, which aims to improve solid waste management in barangays surrounding the pumping stations that will ultimately help maintain the efficiency of pumping stations.

The Project is divided into four (4) main components:

COMPONENT	AMOUNT	IMPLEMENTING AGENCY
Component 1: Modernization of Pumping Stations and Drainage Areas	PhP 18.9 B	DPWH
Component 2: Minimizing Solid Waste in Waterways	**2.4 B**	**MMDA**
Component 3: Participatory Housing and Resettlement	2.8 B	DPWH
Component 4: Project Management and Coordination	**7.2 B**	**MMDA and DPWH**
Indirect Cost – Front End Fee	52.45 M	
TOTAL	**25.11 B**	

Figure 123: Loan Amount for Metro Manila Flood Management Project (Phase 1)

Source: MMDA Metro Manila Flood Management Project

Component I: Modernization of Drainage Areas

This component covers the construction of an estimated 20 new and modernize/rehabilitate an estimated 36 existing pumping stations and appurtenant infrastructure, improve the associated waterways and drainage channels, including secondary and tertiary ones as needed, and develop new drains when required. Modern, efficient and high-capacity pumping units will be installed. Component 1 aims to increase water retention capacity within the project drainage areas. This component will be led by the Department of Public Works and Highways

Pumping station modernization would increase the pumping efficiency and capacity. However, pumping station modernization is not sufficient to provide adequate drainage conditions in the catchment areas of the pumping stations. Waterways/drainage channels will have to be desilted and cleaned of solid waste, both of which affect the discharge capacities, while people obstructing the water flows and maintenance activities may have to be moved away from the waterways/drainage channels.

Component II: Minimizing Solid Waste in Waterways

The project, through Component 2, will carry out activities that will improve the solid waste management system within the communities near the project drainage areas. It intends to introduce improved solid waste collection services, community mobilization and awareness, incentive-based improved waste collection with independently verified results, and neighbourhood upgrading. Possible piloting of innovative waste management opportunities is also being considered in this Component. MMDA is the main implementing agency of this component.

Figure 124: Sustainable Waste Management

Source: MMDA Metro Manila Flood Management Project

Under this component are the six (6) major programs. This involved first the formulation of the Metro Manila Solid Waste Management Master Plan which aims to establish the vision, provide an overall framework for sustainable and effective Metro-wide Solid Waste Master Plan with a planning horizon of 25 years for long-term strategic vision.

Next is the Community-Based Solid Waste Management Program which involve planning & demonstration of community-based SWM interventions such as community organizing & capacity-building; formative research; behaviour Change Communication (BCC) / information, education campaign (IEC); results-based Incentives (RBI); enforcement system and monitoring and Evaluation.

A Solid Waste Granulator Operations and Brick-Making Facility has also been created which is a waste processing technology that aims to prolong the service life of existing landfills through volume reduction of solid waste. Bio-waste and plastics collected in the pumping stations will be used as raw materials which will then be converted into by-products such as bricks, eco-hollow blocks, eco-concrete barriers, and bio-waste compost materials.

Figure 125: Solid Waste Granula Tor and Brick-making Facility

Source: MMDA Metro Manila Flood Management Project

Component II will also involve procurement of Modern Maintenance Equipment, Results-Based Incentives for Barangays and Information, Education and Communication Campaigns.

As a form of result-based incentives for barangays which is the smallest administrative division in the Philippines and is the native Filipino term for a village, district, or ward, the project launched the Market and Collection Day for the Mobile Materials Recovery Facility (MMRF) Activity dubbed as “Recyclable Mo, Palit Grocery Ko” in some of the targeted barangays in Metro Manila. The activity showcased how residents can trade their recyclables for commodities. Residents gain points upon surrender of recyclable materials, which they can

use to redeem grocery items. All participating residents are then provided an Ecosavers Passbook, where all points earned and redeemed are recorded.

Also, under Component II is the conversion of water hyacinth along waterways and in the vicinity of pumping stations into charcoal and other energy forms.

Figure 126: Conversion of Water Hyacinth into Charcoal and Other Energy Forms

Source: MMDA Metro Manila Flood Management Project

One of the pressing concerns in Metro Manila is the presence of water hyacinth that occasionally covers the entire waterway near the pumping stations. Water Hyacinth blocks the natural flow of water as well as affects the efficient operations of the Pumping Station operated and maintained by MMDA.

MMDA provides innovative ways of managing water hyacinths in the vicinity of the PS by implementing innovative technologies in transforming water hyacinths into useful by-products. Water Hyacinths will be used as the basic raw materials for the production of charcoal briquette, compost and biogas.

As a general process, water hyacinths are being collected through a floating harvester and to be transported to the Water Hyacinth Processing Facility staging area. Water Hyacinths will be mixed with African nightcrawlers to produce organic compost. The compost materials will be used in the MMDA's plant nursery, parkways, and plant boxes located along the seven (7) major roads in Metro Manila. Charcoal Briquettes is an end-product of a multi-level process. Water Hyacinths are shredded, dried, carbonized, pulverized, and then moulded into briquettes. Lastly, water hyacinth will undergo an anaerobic process that will produce Bio-Gas electricity. This will contribute to the power requirement of the Water Hyacinth Processing Facility.

This project will serve as a model of innovation in transforming WH into useful eco-friendly products. MMDA will likewise share this technology to the LGUs and private sectors not only to help in collecting WH but will be a source of income generation.

Component III: Participatory Housing and Resettlement

Participatory housing and resettlement aim to support three major groups. The first group pertains to project-affected people (PAP) who were resettled before December 8, 2014. The second group refers to PAPs who were resettled from technical footprints from December 8, 2014, to Project effectiveness. While the third group covers PAPs who will be resettled from technical footprints after Project effectiveness. This component will carry out resettlement programs that will provide easier access to better housing and basic services. It is estimated that about 11,500 people (2,500 families) will be relocated under this Component.

Component IV: Project Management, Support, and Coordination

This component will provide support for the proper operation of the Project Management Offices in DPWH and MMDA. It is expected to provide supervision of Project activities, evaluation and monitoring of the Project, development of communication strategy, and management of grievances.

Green Funds

In terms of the green bond market, the Philippines is the 3rd largest green bond issuer in the ASEAN in 2020. According to the 2020 Philippine Green Infrastructure Investment Opportunity Report, the growth of the green bond market in the Philippines is mostly driven by the private sector.

Figure 127: The Philippines Is the 3rd Largest Green Bond Issuer in ASEAN

Source: Green Infrastructure Investment Opportunities Philippine 2020 Report

The Philippines has developed several funds for supporting green infrastructure and renewable energy projects. They are also eligible to access some regional and international green funds. A domestic initiative, led by the Climate Change Commission (CCC), is the People's Survival Fund (PSF), which was created as an annual fund intended for local government units and accredited local/community organizations to implement climate change adaptation projects that will better equip vulnerable communities to deal with the impacts of climate change.

Green Climate Fund

In terms of the Green Climate Fund, the economy-wide agency in charge for this is the Climate Change Commission which is the National Designated Authority (NDA) in the Philippines.

The GCF is an international fund created by the United Nations Framework Convention on Climate Change to support paradigm-shifting low emission (mitigation) and climate resilience

(adaptation) projects and programs in developing economies. It has a multi-layered approach to mobilize climate finance in the form of investments including grants, loans (concessional), equity, and guarantees. The GCF promotes ownership by central government, and they work closely with the NDA.

Recommendation:

Since the green bond market in the Philippines is mostly driven by the private sector, there is a need to promote the issuance of local green bonds - there is a huge opportunity for the issuance of green bonds at the local government level in the Philippines. This could include incentives such as credit enhancement for the city and municipality.

3.1.2. City with an Industrial Park

Authored by Ping Yean Cheah, AIIB

Industrial parks play a crucial function in an economy and the growth and proliferation of urban areas, particularly in emerging economies. Various studies by IMF, UNDP and World Bank reveal that industrialisation is normally a pre-requisite for a low-income economy to diversify its economy base, sustain growth and transit to middle-income.

The location of these industrial areas is normally in the outskirts of cities and in many emerging economies, they are a source of pollution. Their operating methods, processes are unsustainable and based on the linear model of production.

The World Bank reports that that China's industrial sector is responsible for around 70% of environmental pollution and 72% of its Greenhouse Gas (GHG) emissions. Industrial parks host the majority of these industrial producers or factories. It is logical to surmise that these parks account for the majority of total resource use, pollution and waste of China. In this respect, China has made the promotion of green industrial parks a central aspect of its strategy to "green" industries.

As defined by UNIDO, an eco-industrial park is a *"community of businesses located in a common property in which businesses seek to achieve environmental, economic and social performance through collaboration in managing environmental and resource issues*." In the context of the circular economy, an EIP should promote resource efficient and adopt circular economy practices.

In early 2021, UNIDO, World Bank and GIZ have released a set of standardised approaches for implementation of EIP[215216]. These approaches are driven by a larger Circular Economy concept for Industrial Parks to help manufacturers and park owners to enhance environmental protection, while being economically viable and competitive.

New technologies are being developed and invested in the following park infrastructure areas:

a. Clean energy
b. Water and wastewater treatment, and
c. Material and waste heat sectors.

The Asian Development Bank invested in its first eco-industrial park (EIP) waste-to-energy project in China via a $100 million loan to Shanghai SUS Environment Company (SUS) Ltd.

This project utilises state-of-the-art incineration and emission treatment technologies, treat municipal solid waste sustainably, supply clean electricity to the grid, and have the potential to supply power and stream to treat different types of waste within the EIPs[217].

Another role model park recognised by the Chinese Government as the fourth "Circular District Management" park and part of the second batch of Chinese "Urban Mineral demonstration bases, is the Wuzhou Circular Economy Industrial Park located in Longxu, Wuzhou city, Guangxi Zhuang region. This park was first acknowledged as an information integration and industrial park in 2015, and the following year passed the acceptance test as a "sustainable development experimental zone. Only in 2018, it was awarded the title of National Green Park. Over several years, the park established six major circular economic industrial chains in the following heavy industrial processing areas:

a. Secondary copper
b. Secondary aluminium
c. Recycled plastics
d. Recycled stainless steel
e. Secondary lead and re-manufacturing; and
f. A complete circular industrial chain of "recycling-disassembly-roughing-intensive processing-terminal products and trade integration"[218].

In 2020, the World Bank approved an investment of $200 million for the Jiangxi Eco-Industrial Park, indirectly strengthening Jiangxi province's institutional and regulatory framework for eco-industrial parks. The province's regulations will be aligned to international standards. At provincial level, the project will help establish a pioneering performance management system, upgrade the institutional and policy framework for EIPs, develop zone-level roadmaps, action plans and facilitate learning and capacity-building.

Concurrently, the World Bank is also providing support to the Fuzhou New Industrial Zone, specifically on zero-waste initiatives. This initiative mainly covers reduced use of plastics, improved solid waste management, nature-based solutions, eco-system services restoration such as public "green" space and landscape upgrading, pollution reduction and water quality improvement.

For the Fuzhou Zone, World Bank intervention is expected generate significant climate co-benefits associated with mitigation and adaptation investments, such as "green" buildings, solid waste management and reforestation. These efforts will directly contribute to GHG emission, pollution and urban flood risk reduction in the Zone[219] .

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3.1.3. Medium-Size Town of an APEC Developing Economy – Tomohon

Authored by Mareyke Alelo, Polytechnic Manado, and Brury Bangun, Tomohon

The complexity of urban transportation issues exists in Manado which is currently evolving to a big city that will be part of the BIMINDO Metropolitan area in the future. In 2019, the identification of Manado's infrastructure strategic issues showed that transportation issues held the top position as the most pressing issue to be addressed. The transportation network issues include land, sea, sky and train transportations. Major issues faced by the land transportation network are the 7.7% lightly damaged road and 8.3% damaged road from Manado Road length, multiple traffic jam points throughout the city, dysfunctional roads, parking issues and the high need of inhabitant access to some municipal areas. Some initiatives have been identified to solve these issues such as the development of river transportation, Manado-Bitung train transportation network, Manado LRT, Manado port, and also Sam Ratulangi International Airport.

Manado congestion model shows that in 2019, approximately 21% of Manado main roads experienced congestion. If the governing authority, Manado municipal government, does not create any policies to handle this issue, then the projection in 2028 shows that approx. 40% of Manado main streets will experience congestion and it will keep rising to approx. 52% in 2038. This translates to 1.2%-1.3% annual increase in main roads which experience congestion.

Mass transportation system development is one of the recommended solutions to handle Manado's congestion issues and this need to be gradually implemented in the city's transportation system. By using mass transportation system, it is projected that 30% of public transportation users will convert to mass transportation in 2028, decreasing congestions on main roads.

Carbon emission from transportation sector was calculated using the estimation of fuel supply quantity (BBM) from Pertamina to each Manado gas station (SPBU) that was used up according to quota. It was assumed that 80% was used for municipal activities. The calculation shows that the emission factor numbers from premium and solar are 3.180g CO_2/kg and 3.172g CO_2/kg respectively. The following table shows the carbon emission (CO_2) from transportation sector based on fuel consumption approach in Manado gas stations.

Location	Gas Station	Premium Quota Out of Stock / Day		Premium CO_2 Emission (80 % Assumption)	Solar Quota Out of Stock / Day		Solar CO_2 Emission (80 % Assumption)
		Litre/ Day	KL/ Year	Kg CO_2/Day	Litre/ Day	KL/Year	Kg CO_2/Year
Manado	17	134.355	49.040	96.062.642.676	58.882	21.49193	41.994.199.607

Table 14: CO_2 Emissions from Transportation Sector

Source: Manado Central Bureau of Statistics, 2019

The data shows that each Manado gas station uses up 134.355 litre of premium and 58.882 litre of solar per day for vehicles owned by Manado citizens. If the following programs can be

implemented and the gas consumption can be halved, the amount of CO_2 can also be reduced to 69.028.421.142 kg annually.

Transportation has its part in climate change from greenhouse gas effects. CO_2 as the pollutant source originates from fossil fuel powered moving objects, especially private vehicles (cars and motorcycles). Emission Inventory (IE) calculation results from the collaboration between The Ministry of Environment and Pustral UGM (2019) indicated that CO_2 is a pollutant source and more than 60% of it comes from private vehicles.

As a pollutant source, CO_2 not only has a direct effect on the society but also leads to a drastic global climate change in some regions. The effect of climate change has also happened in Manado such as heavy rains, strong winds, and unexpected weather conditions. As an anticipation to climate crisis, it is needed to have a change in existing activities, individually and collectively, to activities which can reduce mission e.g., public transportation usage.

Manado Integrated transportation development program

Manado integrated transportation development program consists of two existing policies and three new main development policies. The three main policies are elaborated as follows:

1. **Mass Public Transportation Development.** The aims of the activities are:

- The improvement of public transportation service,
- The conversion from private vehicles users to public transportation users.

The activity consists of Bus Rapid Transit (BRT) development:
The activities needed:

1. Bus stops constructions.
2. Bus procurement, 43 vehicles for operational (37 buses) and extra 6 buses.
3. Operational fee funding with an assumption of Vehicle Operational Cost as much as Rp 13.000/km bus.

The estimated fund needed could reach Rp 112.000.000.000,00

2. Public Transportation Integration

The aim of the activity is the convenience of accessibility and public transportation displacement.
The activity consists of TOD area development in 5 (five) locations which are situated along Tondano river.
The activity needed:

1. Mixed use and commercial buildings
2. LRT and BRT Stations
3. Access Roads
4. Pedestrian Tracks
5. Commercial Buildings
6. Parking Lot Buildings
7. Terminal and parking lot buildings
8. Parking Lot
9. Tourism Dock
10. Public Transportation Terminals
11. Tourism Dock BRT Shelter
12. River Dock
13. Pedestrian Way

14. Malalayang Terminal Development
15. Paal 2 Terminal Development
16. Urban Planning
17. Batusaiki Dock Area
18. Tracker installation on toll gates
19. System integration

The estimated fund needed could reach Rp 935.000.000.000,00

3. River and Coastal Transportation

Funding / Water Transportation Investment Cost:

Development of 8 river stops and 9 coastal stops

Procurement of 15 passenger boats (20 passengers each)

Passengers:

Assuming 300 passengers are on-board per trip and each boat operates every 15 minutes (6 rides every day), the total passengers for one day will be 300 x 6 = 1.800 passengers (±5% of citizens in Singkil and Wenang Districts who will opt for this river transportation due to their proximity to Tondano river). Fare for each ride: Rp. 6.000.

Expenditure:

Each boat has 2 crews: Boat Captain (Rp. 3.500.000) + Helper (Rp. 2.800.000).

Fuel: Rp. 250.000 per day/boat.

Boat maintenance is 10 % of boat investment.

Fund Resource:

1st Alternative: Government Fund (APBD)

2nd Alternative: Private Sponsorships

3rd Alternative: Public transportation stops development by government and boat procurement by private sectors (individual/company).

Data analysis:

The estimation of investment period for Tondano river transportation development is 20 years, with 4% discount factor (DF) according to the applied interest rates.

Investment and Operational Funds

The investment and work capital scheme to build this business is shown in table below.

Description	Unit	Price	Total
Investment Cost			
River Stop Development	8 units	300.000.000	2.400.000.000
Coastal Stop Development	9 units	300.000.000	2.700.000.000
Passengers Boat Procurement	15 units	250.000.000	3.750.000.000
Investment Needed			**8.850.000.000**
Operational Cost		**Per Month**	**Per Year**
Boat Captain Wages		94.500.000	1.134.000.000
Fuel		112.500.000	1.350.000.000
Boat Maintenance			37.500.000
Total Operational Cost			**2.521.500.000**
Total Investment and Operational Fund Needed			**11.371.500.000**

Table 15: Investment and Operational Fund Detailed Scheme

Source: Planning Research and Development Agency of Manado

From the table above, it can be seen that the total fund needed is Rp. 11.371.500.000, which consists of Rp. 8.850.000.000 investment fund and Rp. 2.521.500.000 operational cost.

Revenue

Fifteen boats will be procured with a capacity of 20 passengers each. These 15 boats carry 300 passengers in total, with 15 minutes operational time and 6 rides per day. Therefore, each day the boats can carry 1800 passengers. The transportation fee is Rp. 6000, hence the total revenue which can be earned is Rp. 10.800.000/day, Rp. 324.000.000/month or Rp. 3.888.000.000/year.

Figure 128: Project of coastal transportation and Tondano River transportation

Source: Planning Research and Development Agency of Manado

No	Grand Policy	Strategy	Target	Program	Implementation Period							Public Private Partnership Boat Possibility	PIC	Cost (Rp)
					2019	2020	2021	2022	2023	2024 - 2028	2029 - 2038			
1	Traffic Management	Parking and U-turn Policy	Increasing velocity on roads by decreasing side frictions i.e. parking, U-turns and vehicles that stop on curbs.	1. Parking arrangement on curbs: - Jalan RE Martadinata - Jalan Manado – Tomohon - Jalan AA Maramis - Jalan BW Lapian - Jalan Tikala Ares - Jalan Arie Lasut - Jalan Lumimuut - Jalan 14 Februari - Jalan Ahmad Yani - Jalan Bethesda								No	Manado Department of Transportation (Dinas Perhubungan) and Police Department	1,800,000,000
				2. Construction of stop areas for public transportation to stop on the appropriate area in the city center								No	Manado Department of Transportation (Dinas Perhubungan) and Police Department	700,000,000
				3. U-turn arrangement on allowed roads.								No	Manado Department of Transportation (Dinas Perhubungan) and Police Department	270,000,000

No	Grand Policy	Strategy	Target	Program	Implementation Period							Public Private Partnership Boat Possibility	PIC	Cost (Rp)
					2019	2020	2021	2022	2023	2024 - 2028	2029 - 2038			
2	Transportation infrastructure supply improvement	New Network development	Additional network supply to decrease congestion and freight lines.	1.Ring road development								No	The Ministry of Public Works and People's Housing (Kementerian Pekerjaan Umum dan Perumahan Rakyat)	1,300,000,000,000
				2. Bitung-Manado continuous road development								Yes	The Ministry of Public Works and People's Housing (Kementerian Pekerjaan Umum dan Perumahan Rakyat)	6,700,000,000,000
				3. Access repairment through Liwas and finish at Calaca harbor								Yes	The Ministry of Public Works and People's Housing (Kementerian Pekerjaan Umum dan Perumahan Rakyat)	440,000,000,000
				4. Broaden of Wori, Jalan Kairagi – Manado boundary, Jalan Batas Kota Manado								No	The Ministry of Public Works and People's Housing (Kementerian Pekerjaan Umum dan Perumahan Rakyat)	2,200,000,000,000

No	Grand Policy	Strategy	Target	Program	Implementation Period							Public Private Partnership Boat Possibility	PIC	Cost (Rp)
					2019	2020	2021	2022	2023	2024 - 2028	2029 - 2038			
				5. Tomohon toll development								Yes	The Ministry of Public Works and People's Housing (Kementerian Pekerjaan Umum dan Perumahan Rakyat)	4,300,000,000,000
		Transportation knot point development	Intercity , interprovincial bus service implementation	Liwas Type A Terminal Operation								Yes	Ministry of Transportation (Kementerian Perhubungan)	10,500,000,000
			Service improvement for passengers and freights at Sam Ratulangi airport	Runway extension to 3000 metre								No	Ministry of Transportation (Kementerian Perhubungan)	37,000,000,000
3	Mass public transportation development	Demand Management Transport	Conversion from private vehicle usage to public transportations	1. BRT Development								Yes (Collaboration with TOD development investors)	Ministry of Transportation (Kementerian Perhubungan), Sulut Department of Transportation (Dinas Perhubungan Provinsi Sulut), Manado Department of transportation (Dinas Perhubungan Kota Manado)	112,500,000,000

No	Grand Policy	Strategy	Target	Program	Implementation Period							Public Private Partnership Boat Possibility	PIC	Cost (Rp)
					2019	2020	2021	2022	2023	2024 - 2028	2029 - 2038			
				2. LRT Development								Yes (Collaboration with TOD and New City Mapanget development investors)	Ministry of Transportation (Kementerian Perhubungan), Sulut Department of Transportation (Dinas Perhubungan Provinsi Sulut), Manado Department of transportation (Dinas Perhubungan Kota Manado)	2,000,000,000,000
4.	Public Transport Integration	Development of Transit Oriented Development (TOD)	5 TOD locations	Ranging from Bus Stops, Roads, Parking Kots, Pedestrians path, etc								Yes	Ministry of Transportation (Kementerian Perhubungan), Sulut Department of Transportation (Dinas Perhubungan Provinsi Sulut), Manado Department of transportation (Dinas Perhubungan Kota Manado)	935.000.000.000

No	Grand Policy	Strategy	Target	Program	Implementation Period							Public Private Partnership Boat Possibility	PIC	Cost (Rp)
					2019	2020	2021	2022	2023	2024 - 2028	2029 - 2038			
5.	River and Coastal Transportation	Development of river and coastal stops, and passenger boats operation	8 River Stops 9 Coastal Stops 15 Passenger boats Operation and Maintenance	- Construction of boat stops; - Procurement of passenger boats;								Yes	Ministry of Transportation (Kementerian Perhubungan), Sulut Department of Transportation (Dinas Perhubungan Provinsi Sulut), Manado Department of transportation (Dinas Perhubungan Kota Manado)	11.371.500.000

Table 16: Manado Integrated Transport Development Program

Source: Planning Research and Development Agency of Manado

3.1.4. Example of a Catalytic Role of a City-Level Fund: Shanghai

Catalytic effects can occur in several types. The section on the Green Climate Fund (section 2.4.3) described the example of the Beijing-Tianjin-Hebei region where the GCF used its funds to catalyse private investors in a catalytic factor of eight. The theory behind this kind of catalytic effect that has been described in section 2.3.3.

The present section briefly describes a different type of catalytic effect related to the development and financing of urban low-carbon transition. The Shanghai special fund for energy conservation and emission reduction uses the mechanism of increased cooperation between different administrative units of the city to bring about a catalytic effect[220].

The study analysed altogether 12 policy domains, consisting of 41 subsidy policies, and 167 subsidized projects. The scope of the study was primarily to determine how allocated funds are used to enable low carbon transition.

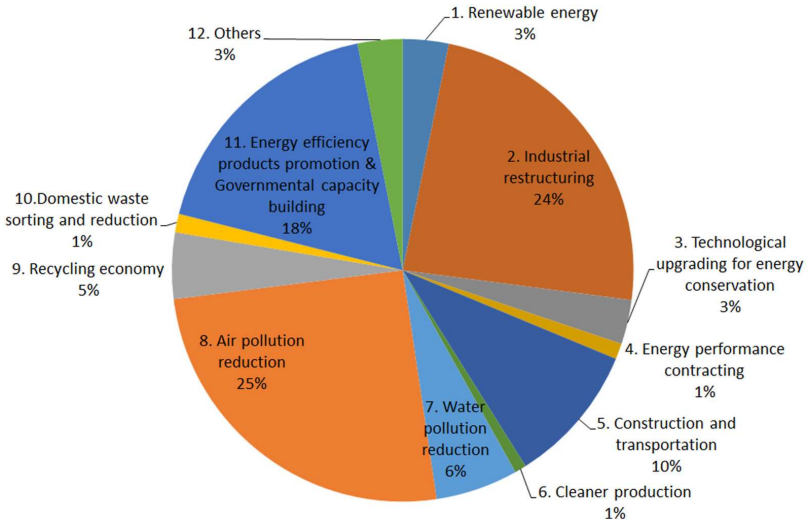

Figure 129: Policy domains analysed for Shanghai

Source: Peng & Bai [221]

- A linkage analysis is applied to understand the effectiveness of this scheme in enabling collaboration between institutions
- The direct results of Shanghai's special fund scheme include carbon reduction outcome and a variety of tangible capacity building activities, such as data reporting systems and demonstration projects
- The fund plays a catalytic role in enabling coordination and collaboration across different government departments on cross-cutting policy domains. Altogether 21 subsidy polices managed by 23 urban institutions have been analysed. In average there are five institutions overseeing a project. The analysis shows the existence of 315 links between the institutions managing the projects
- The special fund may have enabled local capacity building in multiple ways, through financing the governmental capacity building, incentivizing engagement from other stakeholders, and raising public awareness
- The study also shows that a well-designed, city-level direct fund scheme can fill an implementation gap between the policy outputs and the policy outcomes

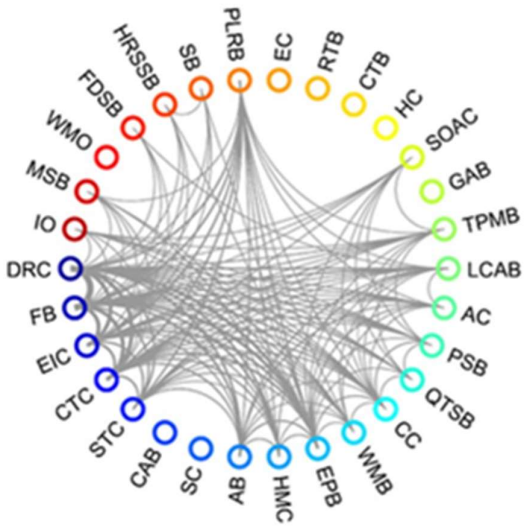

Figure 130: Linkages between policy areas, Shanghai

Source: Peng & Bai [222]

3.2. The Different Roles of Cities

3.2.1. Cities as Policy Makers and Regulators promoting Carbon Neutrality

The purpose of analysing different roles of cities is to explore the possibilities of cities to improve their possibilities to act on the pathway towards carbon neutrality. Each role described hereafter might in effect contribute to the design of local solutions to improve sustainability and resilience of cities, and to help generate or mobilize the necessary finance.

Cities and local governments have been part of the global governance for sustainable development since the United Nations Conference on Environment and Development (UNCED) held in Rio de Janerio, Brazil, from 3 to 14 June 1992. This Conference had been preceded by the Brundtland Report in 1987 formulating the basic definition of sustainability as a “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. The UNCED was a milestone among the global events promoting sustainability.

One of the outputs of the UNCED conference was Agenda 21[223]. Agenda 21 is a 350 page to-do-list of activities destined to enhance sustainability in the socio-economic and environmental dimensions, by strengthening the role of major groups, and by defining means of implementation. Among the major groups figure the local authorities (see chapter 28 of the Local Agenda).

The concept of Local Agenda 21 invited all levels of government to address sustainability. The Local Agenda 21 has the following objectives:

a) By 1996, most local authorities should have undertaken a consultative process with their populations and achieved a consensus on "a local Agenda 21" for the community

b) By 1993, the international community should have initiated a consultative process aimed at increasing cooperation between local authorities

c) By 1994, representatives of associations of cities and other local authorities should have increased levels of cooperation and coordination with the goal of enhancing the exchange of information and experience among local authorities

d) All local authorities should be encouraged to implement and monitor programmes which aim at ensuring that women and youth are represented in decision-making, planning and implementation processes

Even though Local Agenda 21 is a voluntary process of local community consultation, it managed to commit 6'500 local governments worldwide to start a Local Agenda 21 process by 2001[224].

The Local Agenda 21 is far from being a commitment to become climate-neutral or carbon-neutral. However, the Local Agenda 21 helped in creating participative processes at local level which can be used in future to address similar development challenges, such as carbon neutrality and climate neutrality. Such participation should lead to informed decisions at local level, mirroring the corresponding decision-making processes taking place at international level. At international level, the following stakeholder groups recognized by Agenda 21 are

- Women
- Children and Youth
- Indigenous Peoples
- Non-Governmental Organizations
- Local Authorities
- Workers and Trade Unions
- Business and Industry
- Scientific and Technological Community, and
- Farmers

The role of cities has further been enhanced by the 2016 Habitat III Conference held in Quito, Ecuador. This Conference, which gathered around 30'000 delegates from UN Members as well as their relevant stakeholders, including parliamentarians, civil society organizations, regional and local government and municipality representatives, professionals and researchers, academia, foundations, women and youth groups, trade unions, and the private sector, as well as organizations of the United Nations system and intergovernmental organizations, basically translated the SDGs adopted a year earlier to the local level. Its primary goal or outcome is reflected in the New Urban Agenda (NUA)[225]. The NUA is not about carbon neutrality nor climate neutrality. The NUA does not even contain these terms.

In 2017, the C40 Cities Climate Leadership Group launched a specific voluntary commitment called the Clean and Healthy Streets Declaration[226] aiming at procuring only zero-emission buses from 2025; and ensuring that a significant part of the city is zero emission by 2030. This commitment is now part of the Zero Emission Area Program[227]. Participating APEC cities are Auckland, Austin, Honolulu, Jakarta, Los Angeles, Mexico City, Moscow, Paris, Santa Monica, Santiago, Seattle, Seoul, Tokyo, Vancouver, and West Hollywood.

Going beyond the above-mentioned objectives of the C40, the Carbon Neutral Cities Alliance (CNCA) has been created in Copenhagen in June 2014 by Mayors of 17 international

cities[228] working to achieve carbon neutrality before 2050. While it is possible for cities to achieve interim carbon reduction targets through incremental improvements to existing systems, achieving carbon neutrality requires radical, transformative changes to core city systems. CNCA counts 22 city members, of which the following 13 are APEC cities[229]: Adelaide, Boulder, Melbourne, Minneapolis, New York City, Portland, San Francisco, Seattle, Sydney, Toronto, Vancouver, Washington DC, Yokohama. Among the founding cities was also Boston, which apparently has dropped out. CNCA is staffed by the Urban Sustainability Directors Network (USDN) headquartered in Washington DC, in partnership with the Innovation Network for Communities (INC), and C40 Cities Climate Leadership Group (C40).

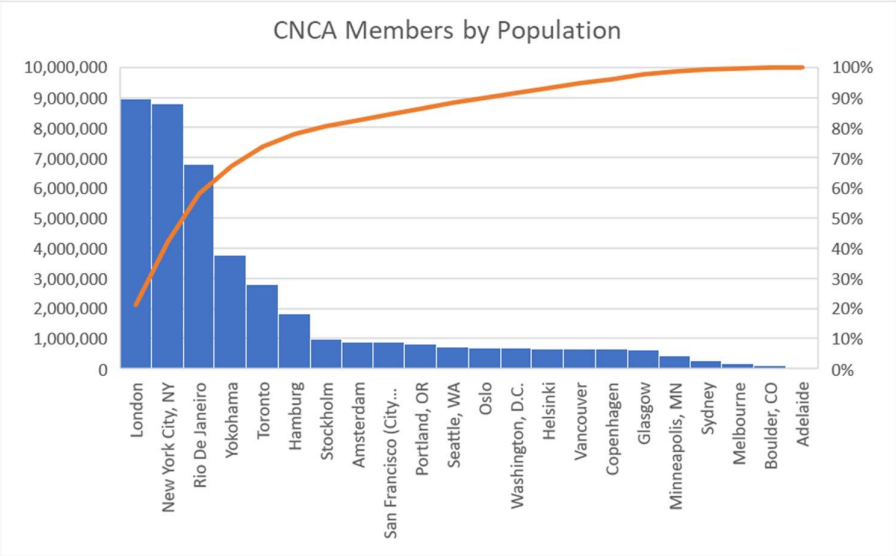

Figure 131: Carbon Neutral Cities Alliance (CNCA) Members

Source: APSEC, based on data of Climate Action [230]

The CNCA Steering Committee has set 30 as the maximum number of members. To participate in the carbon neutral cities alliance (CNCA), a city must fulfil high membership criteria[231]:

1. City Council has formally adopted community-wide carbon neutrality goal across all sectors (electricity, thermal, transportation, waste).

2. City has developed, or is currently developing, community-wide carbon neutrality implementation plan.

3. City has dedicated budget and staff allocated to implementing its carbon neutrality implementation plan.

4. City is committed to active participation in the Alliance (interested in learning from other cities, committed to sharing with other cities, and committed to advancing urban carbon neutrality goals globally).

In the CNCA 2021-2023 Strategic Plan the Alliance has seven Strategic Goals[232]:

1. Funding transformative climate action to mobilize the development, adoption and implementation of game-changing climate policies in cities.

2. Exerting collective influence on and advocate for policies from other decision-makers to reduce emissions not directly controlled by cities.

3. Advancing methodologies, standards and governance tools for carbon neutrality planning, implementation, impact measurement and continuous improvement.

4. Fostering peer learning among climate vanguard cities, so they can learn from each other and go further and faster together.

5. Cultivating transformational leadership so city sustainability directors can excel in their roles as change-makers.

6. Helping cities communicate more effectively to advance their carbon neutrality work.

7. Prioritizing a just carbon neutral future by integrating climate justice into ambitious climate action.

Carbon neutrality has gained impetus at COP 25 held in Madrid, Spain, in December 2019. At that occasion, Chile announced the creation of a Climate Ambition Alliance, and was immediately joined by 73 parties to the UNFCCC, 14 regions, 398 cities, 768 businesses and 16 investors, all having the aim of working to achieve net-zero GHG emissions by 2050[233]. A campaign to recruit new members has been created and called Race to Zero in June 2020. In the following months the campaign defined two sets of criteria for new members to become member of the Alliance: “Starting Line” and “Leadership Practices”, respectively.

Pledge	Pledge at the head-of-organization level to reach (net) zero GHGs as soon as possible, and by midcentury at the latest, in line with global efforts to limit warming to 1.5C. Set an interim target to achieve in the next decade, which reflects maximum effort toward or beyond a fair share of the 50% global reduction in CO2 by 2030 identified in the IPCC Special Report on Global Warming of 1.5C
Plan	Within 12 months of joining, explain what actions will be taken toward achieving both interim and longer-term pledges, especially in the short- to medium-term.
Proceed	Take immediate action toward achieving (net) zero, consistent with delivering interim targets specified.
Publish	Commit to report publicly both progress against interim and long-term targets, as well as the actions being taken, at least annually. To the extent possible, report via platforms that feed into the UNFCCC Global Climate Action Portal.

Table 17: “Starting line” criteria of the Race to Zero

Source: Race to Zero, UNFCCC[234]

Scope	Targets must cover all greenhouse gas emissions: 1. Including Scope 3 for businesses and investors where they are material to total emissions and where data availability allows them to be measured sufficiently. 2. Including all territorial emissions for cities and regions Leading targets may also include: 1. Cumulative emissions (for all actors) 2. Consumption emissions (for cities, states, and regions)
Sinks and credits	1. In the transition to (net) zero, prioritize reducing emissions, limiting any residual emissions to those that are not feasible to eliminate. 2. Clearly specify what sinks or credits are used to make what, if any, neutralization claims, clarifying how sinks and credits are used both on the path to (net) zero, and after (net) zero is obtained. Any neutralization of residual emissions must transition to permanent removals by the time (net) zero status is achieved.
	3. Encourage immediate contributions to the preservation and restoration of natural sinks, not necessarily linked to neutralization claims. 4. Ensure that any credits achieve robust outcomes for additionality, permanence, and accounting, and do not undermine social justice or harm biodiversity.
Empowerment and equity	Seek to enable all actors to contribute to the global transition toward (net) zero through engagement, information sharing, access to finance, and capacity building. Develop pledges, plans, and actions in consideration of equity, drawing on, inter alia, the Sustainable Development Goals and Articles 2 and 4 of the Paris Agreement.

Table 18: "Leadership Practices" criteria of the Race to Zero

Source: Race to Zero, UNFCCC[235]

The Alliance is open to all levels of government, as well as investors, organizations, and companies. In this framework, the Alliance has grown to become a truly global network. The Global Climate Action portal[236] shows the updated list of participating members of all the six membership categories. 196 economies, 267 regions, 11'355 cities, 1'515 investors, 334 organizations, and 11'785 companies participate. Within the Alliance, members may participate in many different initiatives (currently: 151)[237], see the list in Annex 2. All initiatives are characterized along four different dimensions, namely:

- Thematic area (categories: land use, oceans and coastal zones, water, human settlements, transport, energy, industry, adaptation/resilience, finance),
- Climate focus (categories: mainly adaptation/resilience, mainly mitigation, equally adaptation/resilience and mitigation)
- Initiative functions (categories: knowledge production, knowledge dissemination, technical implementation, institutional capacity building, norm and standard setting, campaigning, lobbying, increasing participation, training, funding, product development, policy planning)
- SDGs (categories: 1 to 17)

As a first example of an initiative that is relevant to this report, take as the "Cities Climate Finance Leadership Alliance (CCFLA)". It is a multi-level and multi-stakeholder coalition committed to deploying finance for city level climate action at scale by 2030. Launched in 2014 in London, its mission is to catalyse and accelerate additional capital flows to cities, maximize investment in low-carbon and climate-resilient infrastructure, and close the investment gap in

urban areas by 2030. Its currently 46 participants comprise 4 companies, 14 investors and 28 organizations, all named on the website[238].

Figure 132: Cities Climate Finance Leadership Alliance

Source: Climate Action, UNFCCC[239]

Goals: The Cities Climate Finance Leadership Alliance is a coalition of leaders committed to deploying finance for city level climate action at scale by 2030. The Alliance aims to close the investment gap for urban climate projects and infrastructure worldwide.

Participation criteria: Participants of the Alliance are organizations (not individuals). There are no fees for participation in the Alliance. In order to join the Alliance as a new member, a contact point from the organization must submit a brief questionnaire with relevant information about activities that the organization undertakes related to local climate finance, and a letter of commitment from a leader of the organization. All applications are reviewed and must be approved by the Alliance Steering Committee. Additional membership information is available here[240].

Actions undertaken: Key achievements and success stories:

Various news items can be found here[241].

The State of Cities Climate Finance 2021 report is available here[242].

Project Preparation Glossary is available here[243].

Harmonized Application Project Preparation Application Form is available here[244].

Green Finance Directory is available here[245].

The Alliance Forum for Subnational Project Preparation Practitioners in Mexico Event Report is available here[246].

Prep Course: The ABC for Preparation of Projects of Successful Investment is available here[247].

Deliverables & output: Publication of research by the initiative; Publication of advocacy or campaign material; Publication of new norms, standards, procedures, or practices; General reporting; Public databases or platforms; Funding disbursed for a project; Event organization: science-related; Event organization: policy-related; Event organization: popular or general audiences; New partners: new stakeholders or members, engaged as participants

A second example of an initiative that is relevant to this report, take the Global Alliance for Buildings and Construction (GlobalABC). It has been founded in 2015 by UNEP with 195 members, and is the leading global platform for governments, private sector, civil society, research, and intergovernmental organizations committed to a common vision: A zero-emission, efficient and resilient buildings and construction sector[248].

Figure 133: Global Alliance for Buildings and Construction (GlobalABC)

Source: Climate Action, UNFCCC[249]

GlobalABC has 179 participants, comprising 21 companies, 2 investors, 113 organizations, 4 regions (including California and Province of Ontario), 6 cities (including APEC cities Mexico City and Tokyo), 33 economies (including 9 APEC economies).

More information, including on goals, targets, dedicated staff, monitoring arrangements, participation criteria, budget, actions undertaken, deliverables & output, as well as challenges & opportunities of this initiative can be found on the indicated website.

A third example of a relevant initiative is the District Energy Accelerator, created in 2014[250]. It comprises seven (European) companies, nine organizations (including the International District Energy Association and the US Department of Energy), and 19 cities, among them five APEC cities (Anshan, Jinan, Seoul, St. Paul, Vancouver)

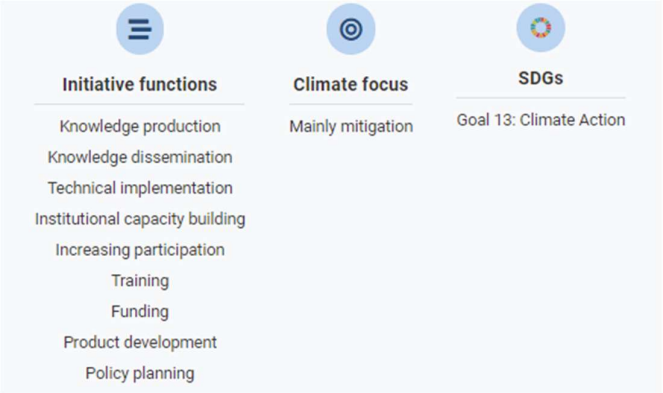

Figure 134: District Energy Accelerator

Source: Climate Action, UNFCCC[251]

3.2.2. Cities as Land Planners

Cities have been land planners for long time. 20th century urban planning uses zoning or land planning as important planning tool. Euclidean or "classical" urban zoning[252] established in the 1920s distinguishes four types of urban land zones, namely single family residential, multi-family residential, commercial, and industrial. Since then, this typology has been somewhat diversified by adding sub-categories, e.g., two-family residential, elevator-residential, retail commercial, wholesale commercial, light industrial, heavy industrial zones, or by adding new categories such as governmental or educational land zones.

Urban planning of the 21st century adds at least two more types of land zones, namely transportation land (for all types of urban transport), and recreational land, comprising open spaces, parks etc. For coping with the high urbanization rates that many APEC cities have experienced in past decades or are still experiencing, the construction of high-density cities (> 15'000 inhabitants/km2) is a necessity. As experience shows, single-function zoning is not the most land-efficient planning method; mixed zoning allows for more parsimonious land use. Furthermore, residential zoning should at least distinguish between affordable housing and other housing. The decreasing role of heavy industry and the appearance of new forms of less invasive medium and high-tech industries favour the proximity or merger of the light industry zones with educational zones comprising science and technology parks of universities, or with wholesale commercial land zones, which can then conveniently be called economic zones. The shared economy favours the creation of residential hotels or apart-hotels, mixing residential with commercial land zoning. With super-tall buildings (>300m height), vertical zoning becomes normal, mixing residential, hotel, retail commercial, office, and possibly a subway transit hub all in one single high-rise zone. Compared to Euclidean zoning, these latter are all forms of mixed zones.

Considering the high density of >15'000 inhabitants/km^2, one could be made to believe that future energy-efficient and emissions-poor cities will all be skyscraper cities. This is not necessarily the case. In fact, the life-cycle analysis of high-density high-rise urban environments (e.g., Manhattan) shows that they score relatively worse than high-density low-rise environments (e.g., Paris or Barcelona)[253]. The striking difference originates from the elite materials needed to build them (e.g., steel, reinforced concrete, aluminium and glass) which all require high quantities of embodied energy and emissions. With similar life span (e.g., 60 years) high-density high-rise buildings score worse than high-density low-rise buildings.

Mixed zoning described above represents one part of the effort to efficiently managing daily commuting. The other part is made by transit-oriented development (TOD)[254], a type of development putting transit hubs into the centre of neighbourhood planning. Both, mixed zoning and TOD are important ways to improve daily commuting and energy efficiency. Mixed zoning can make superfluous some types of journeys. The Five Principles of Sustainable Neighbourhood Planning adopted in 2015 by UNHABITAT concretize the idea of TOD.

Formula	Unit	Principle
Street land-use / Total floor area	(30-45%)	Principle 1
Population density	(15-60 k people/km²)	Principle 2
Economic floor area / Total floor area	(40-60%)	Principle 3
Residential floor area / Total floor area	(30-50%)	
Single tenure / Residential floor area	(0-50%)	Principle 4
Affordable housing / Residential floor area	(20-50%)	
Single function block area / Neighbourhood area	(0-10%)	Principle 5

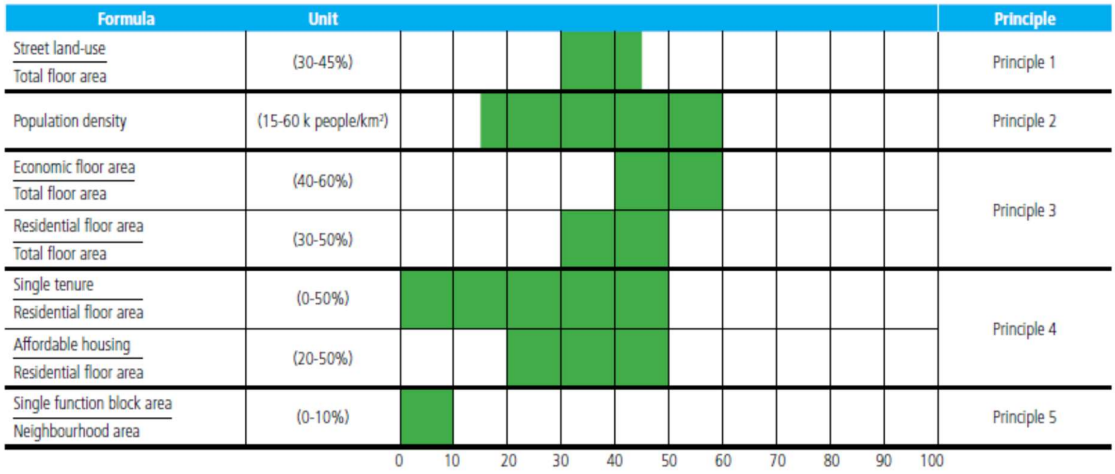

Table 19: Five Principles of Sustainable Neighbourhood Planning

Source: UNHABITAT[255]

Principle 3 provides for mixed economic-residential neighbourhoods, whereas principle 4 provides for a mix between single-tenure and affordable neighbourhoods. The necessity to provide for sufficient floor area for affordable housing in the neighbourhood of transit hubs is particularly important. It is the key principle for guaranteeing that public transport or transit systems remain financially profitable. The lower income quintiles are more than others dependent on the services offered by the transit system. In the absence of Principle 4, the transit hub generates gentrification in its neighbourhood, driven by rising land prices, which favour households using one or more cars instead of using the transit system. This market segment will profit from the rich services offered in the neighbourhood of transit hubs, but will not finance the transit system, thereby contributing to the lack of financial viability of the transit system which is the main growth engine of the neighbourhood.

Some case examples can illustrate the effect of insufficient transit-oriented development.

Wangjing city in the northeast of Beijing, halfway between the city centre and the Beijing Capital International Airport, has a futuristic and otherwise rich infrastructure, but its iconic Soho towers are almost two kilometres away from the next subway station.

Figure 135: Wanjing Soho towers, Beijing

Source: 10wallpaper.com[256]

Another example, Sejong City, the new administrative smart and green capital city of Korea, which is still under construction until 2030, is being built more than 35 kilometres away from the next railway station. Its public transport system is composed of bus services. Hundreds of buses transport the government officials back and forth to Seoul where most of them still live.

3.2.3. Cities as Waste Managers

Waste treatment is an area which makes a decisive contribution to carbon neutrality and where urban planning plays an important role. The overarching objective of the circular economy is to transform waste to wealth. Waste can be solid or liquid; waste treatment therefore includes wastewater treatment as well as waste combustion. Untreated waste emits methane in considerable quantities, a GHG that has 86times more greenhouse potential than CO_2. Waste treatment is a core responsibility of local communities who can and should act at each level of the waste hierarchy.

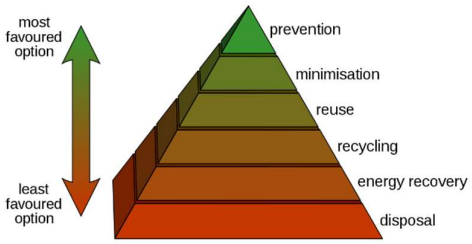

Figure 136: Waste hierarchy

Among the areas needing land planning at city level is waste treatment. In APEC, waste treatment has received some attention in the past. Up to now, APEC has approved 33 projects combining both, waste and urban focus (see Annex 1 List 3 at the end of this report). While the EWG has sponsored 21 of these, 9 other committees sponsored the other ones. Some of these committees are like the EWG placed under the SCE (SOM Steering Committee on Economic and Technical Cooperation: IST and its successor PPSTI, OFWG, ATC), while others are under the Committee on Trade and Investment (CTI: SCSC) and one is independent (PPFS). Waste management is in principle a subject for cooperation. A special mention is given here to the APEC Guidebook for the Development of Sustainable Cities Focusing on Resource Circulation and Waste Management[257] which outlines an overall strategy for urban waste management for the APEC region.

A specific aspect of waste management is wastewater treatment. APEC has approved altogether 12 projects touching the subject of wastewater, of which 11 equally touch the subject of energy, see Annex 1 List 4 at the end of this report. From this, the conclusion can be drawn that the energetic relevance of wastewater treatment has been generally acknowledged in APEC cooperation. The primary energy density of wastewater is around $10^7 J/m^3$ of wastewater[258], equivalent to 2.7Wh/l, or hydropower with 1000m height difference, of which about one fifth is used for the wastewater treatment itself. In the figure further above, wastewater could be placed near pumped hydropower storage (PHS) and compressed air energy storage (CAES). For cities, this means that wastewater is a renewable energy source like hydropower but is sourced clearly within city boundaries. The conversion of sewage sludge to biochar has recently received greater attention[259260]. Biochar which can be produced from

wastewater sludge after treatment (see section 2.1.3), is a polyvalent material that can be used in dozens of ways not limited to agriculture but extending to industry and construction. Blending concrete with a certain percentage of biochar can give rise to carbon-negative concrete[261]. Biochar could become an important building material to make future cities carbon neutral or even carbon negative. This shows why cities and municipalities should integrate wastewater into their next decades urban planning.

3.2.4. Cities as Infrastructure Operators

Cities are infrastructure operators in a great number of areas and infrastructure types. Some infrastructures such as wastewater treatment have been described in the preceding section. Cities, towns and municipalities, can reap multiple benefits if they set them up to improve their sustainability. Wastewater infrastructure can be mentioned specially as it is the only infrastructure that has a triple significance for energy, water and waste management.

The diagram hereafter names the most important infrastructures that are relevant for urban sustainability. Infrastructures without brackets are taken from the American Society of Civil Engineers (ASCE)[262] and are, therefore, recognized as urban infrastructures. The 2021 ASCE report, compared to preceding editions, added the stormwater infrastructures as a novelty, considering that more and more US cities struggle against stormwater as a consequence of climate change.

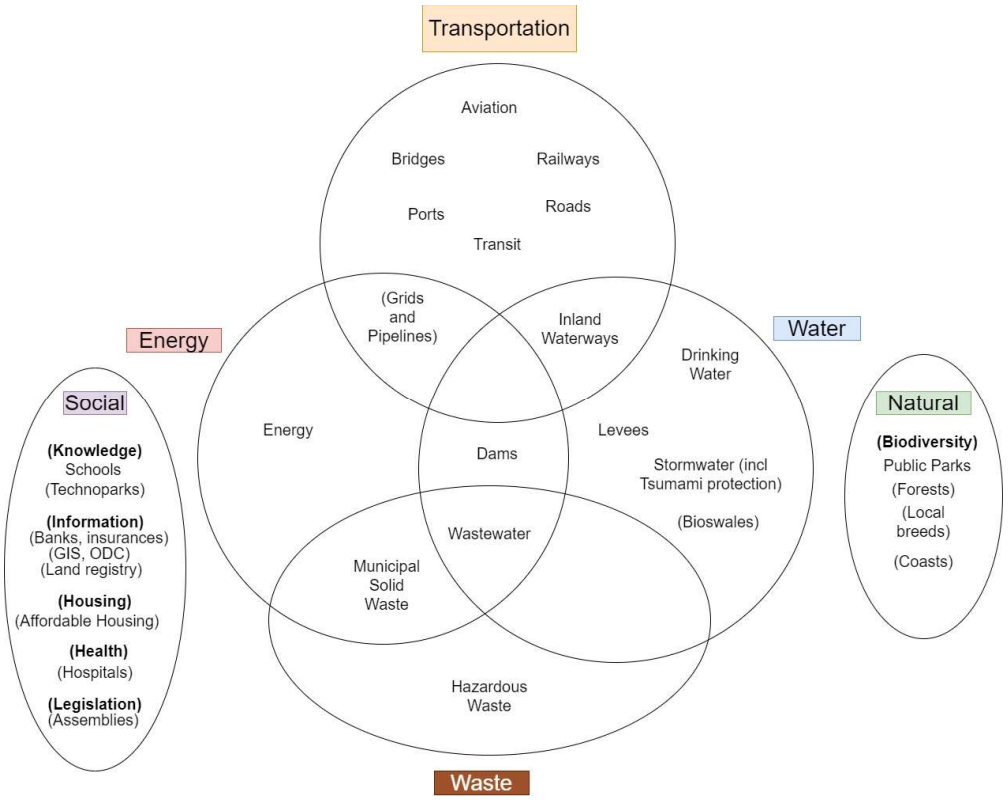

Figure 137: Urban infrastructures

Source: APSEC

The infrastructures placed in brackets in the above figure are those that can be added in a global holistic approach or in an approach based upon the SDGs. Additions concern above all the social and natural infrastructures. Among the social infrastructures, ASCE only considers schools, and among the natural infrastructures they only consider public parks. Social and natural infrastructures are increasingly important for disaster resilience. The Disaster Resilience Scorecard for Cities contains one entire section on “Safeguard Natural Buffers to Enhance the Protective Functions Offered by Natural Ecosystems” (“Essential 5”). Protective infrastructures offer specific ecosystem services such as:

- Sand dunes, coastal wetlands, mangroves or reefs that protect against storm surges and tsunamis
- Forestation that protects against flash flooding, landslides
- Natural overflow channels, sandy soil soak-zones, and marshes that can protect against river flooding and storm water run-off
- Lakes, rivers and aquifers that supply water
- Water-tables that, if lowered, may cause low-lying or reclaimed land to shrink to below sea level
- Trees and greenery that reduce urban heat-island effects or enable urban soak-way zones for flood management.

The latter include the more specific green infrastructure: greening streets, squares and roadsides; greening roofs and facades, developing urban agriculture; creating urban green corridors; replace impermeable surfaces; natural water filtration; daylighting urban rivers and restoring embankments, etc. The blue infrastructure in the narrow sense includes the river corridors, wetlands and other waterways.

In the area of social infrastructures, the Disaster Resilience Scorecard for cities is going far beyond the above. The social institutions that matter most for increasing disaster resilience can be grouped in two categories:

- Organizations strengthening the societal capacity for resilience (“Essential 7”), comprising; community or “grass roots” organizations, social networks, private sector / employers, and citizen engagement techniques
- Organizations strengthening Institutional Capacity for Resilience (“Essential 6”), comprising among others those raising skills and experience, public education and awareness, data capture, publication and sharing, training delivery.

3.2.5. Cities as Partners in Public Private Partnerships (PPP)

Examples of PPP have been given in section 2.2.8. The role of public private partnerships to accede to technology has also been described in the APEC Integrated Urban Planning Report – Combining Disaster Resilience with Sustainability[263]. The different types of PPP have been presented according to the respective role played by the public or the private sector, respectively, see figure below. Whereas the bottom left shows PPP models having preponderant investment and risk share of the public sector, the top right shows PPP models having preponderant investment and risk share of the private sector.

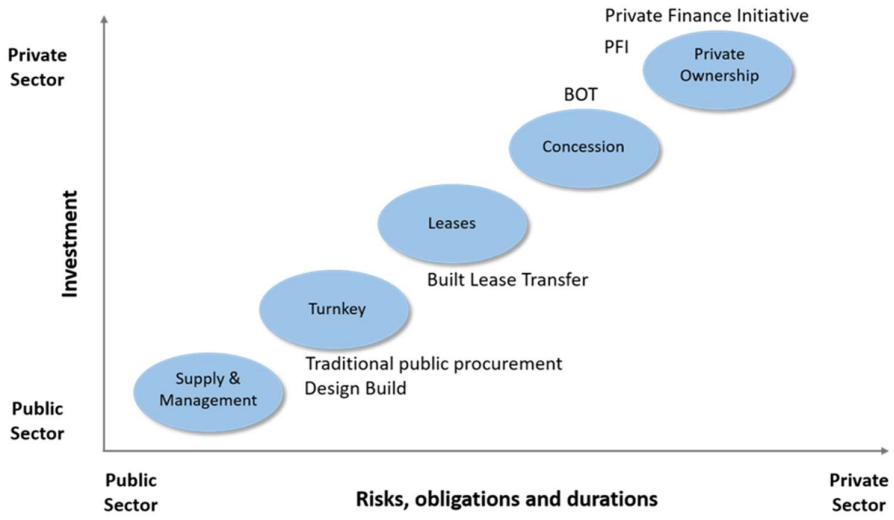

Figure 138: Models of public private partnerships PPP

APSEC based on UNESCAP[264]

In this report, the focus lies on PPP as means to generate green finance. The PPP forms which are predestined to this function are the upper right ones. Concessions and BOT (Build Operate Transfer) schemes are PPP forms in which the public partner basically sets the framework, and the private partner does all the rest, which includes raising the finance to cover the investment cost. After the convened period of operation, the concession returns to the public partner. The PFI (Private Finance Initiative) is giving the private partner the possibility to retain ownership after the end of the operation period.

If either of these two PPP forms are applied in building renewable energy production facilities, they generate green finance.

The role of PPP is essential in the energy transition where, as stated in Chapter 1, a considerable financial gap must be breached. Public finance will by no means be able to do this task alone. For this, it needs to attract or to catalyse private finance. PPPs can be an instrument of choice to catalyse private finance.

3.2.6. Cities as Procurers and Consumers

The situation regarding sustainable procurement and consumption of cities is somewhat like the one described further above in the section concerning ESG. The substantive difference may be that the “G” in ESG is replaced by an “E” in sustainable procurement, standing for economic impact.

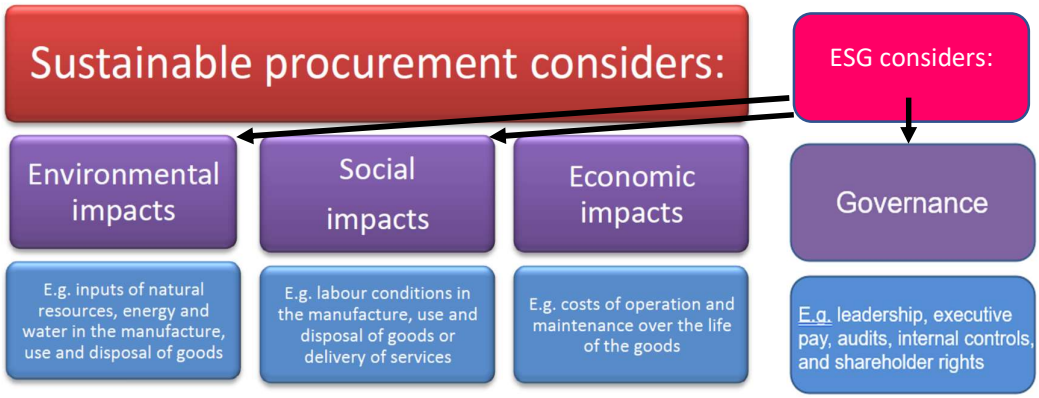

Figure 139: Sustainable procurement and ESG compared

Source: APSEC

More important is the difference of originator between ESG and sustainable procurement. While ESG is all about investor relations, in which investors choose the type of relations, sustainable procurement is about supplier relations, in which the procuring agents choose the type of relations. Cities and municipalities are more likely to be originators for procurement which gives them the possibility to shape procurement relations and are at the same time being impacted by ESG originators and hence subject to conditions set by investors. Big cities are, however, also big investors and can, therefore, impact their investor relations.

Sustainable procurement has been pushed after the 1992 Rio Summit and is, therefore, older than the SDGs. SDGs address sustainable procurement in SDG 12 (responsible consumption and production). In 2017, ISO has adopted the ISO Standard 20400 providing guidance to organizations, independent of their activity or size, on integrating sustainability within procurement. This standard is elaborating corporate social responsibility as described in ISO 26000. According to the official description of this standard[265], ISO 20400 is not only addressing SDG 12, but also SDG 1 (no poverty), SDG 2 (zero hunger), SDG 5 (gender equality), SDG 8 (decent work and economic growth), SDG 10 (reduced inequality), SDG 11 (sustainable cities and communities), and SDG 16 (peace, justice and strong institutions).

The role of procurement in promoting renewable energy cannot be sufficiently emphasized. The Power Purchase Agreement (PPA) presented in section 2.2.7 shows the relevance and leverage of municipalities to use procurement for generating electricity. While until recently, procurement had to be green by choice of cities, as green products were more expensive than normal ones, this may have changed recently due to the drop of producer cost of renewable energy. Henceforth, as renewable energy is often the cheapest source, the rules of “classical” procurement, aiming at minimizing costs, may also best promote renewable energy.

Costs of renewables have fallen due to learning curves[266]. While Moore’s Law[267] is known to describe and predict cost diminution in information technologies, Swanson’s Law makes similar predictions for solar PV[268]. However, to be able to profit from these price decreases, cities must adopt the correct procurement method, namely competitive international tendering. It is thanks to such tendering methods that buyers can profit from record low solar prices. Thus, in April 2021, the lowest price stood at $0.0104/kWh[269], hit in a competitive international tender held by Saudi Arabia. The traditional function of tendering, namely, to receive the lowest possible cost-benefit ratio, is essential for disseminating the benefits of clean energy to the widest possible number of people.

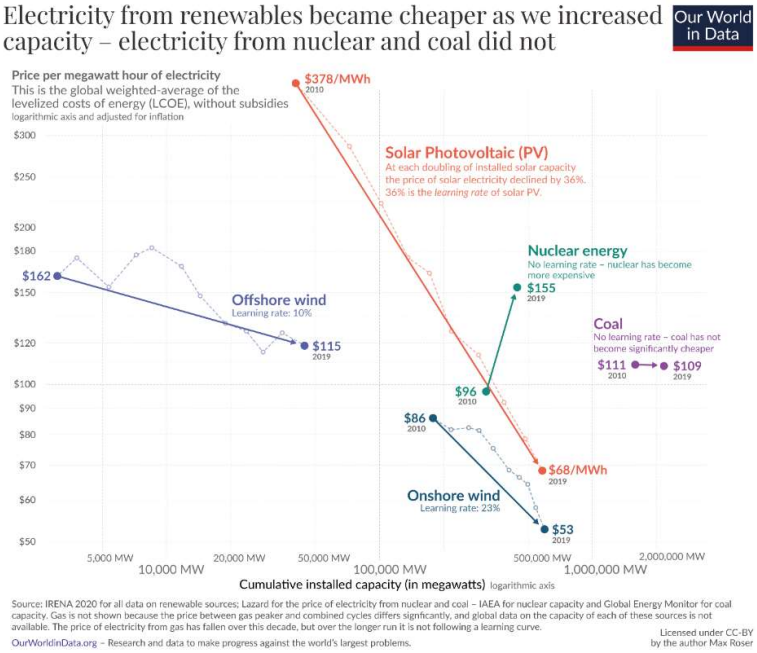

Figure 140: Learning curves for different energy forms

Source: Max Roser[270]

This example shows how important it is to consider the primary objectives when applying procurement policies. In some cases, as for increasing production of renewable energy, straightforward competitive international tendering might be the best option. Many examples exist where local or central authorities have tried to satisfy a cohort of other objectives when tendering for energy production capacity, with the result that none of the objectives could be attained.

As described further above, the high importance of affordable housing near transit hubs is also essential to guarantee the success of the transit system and the transit-oriented development that accompanies it. Possibly, competitive international tendering could help also in this case to bring down the cost of housing to the required level guaranteeing affordability of the settlement.

Besides these two special cases where the cost-benefit ratio is essential, many examples can be found where a broader set of procurement criteria is added. The most common addition is taking the life cycle cost which includes cost borne by the buyer at a later moment in time, or different forms of external or hidden or social costs borne by other actors, especially actors that have a kind of relationship with the buyer. In all these cases the degree of knowledge of these additional cost types is essential. The less well such cost can be established, the more hazardous is the associated procurement.

Sustainable procurement can act efficiently by excluding certain options from entering an evaluation at all (e.g., manufactured products from child labour, wood products from non-FSC certified forests, leather or fur types from endangered species). For driving the transition towards clean energy, energy-related procurement can gradually decrease the proportion of allowable fossil-based energy. In this manner procurement can become a driving force for change. Cities can participate in this process and drive the change.

Green procurement is a variant of sustainable procurement in the sense that green procurement gives higher importance to environmental than to social concerns. Sometimes it is also argued that green procurement is barely considering social issues.

Green procurement and green finance distinguish themselves from ordinary procurement and ordinary finance mainly by the specific activities which are being supported, either by procurement or by credits and loans. To create clarity and avoid abuse of the terms “green procurement” and “green finance”, some jurisdictions have defined precisely what the green or clean sector consists of. These definitions are known as taxonomies, see the section 2.1.1.

3.2.7. Cities as Data Producers

A very important aspect of the life of cities and municipalities is related to the way they communicate with their citizens or with the public at large. Basically, all the activities of cities as described in the preceding sections can and should be the object of structured communication. Cities should publicise what they have accomplished or plan to accomplish regarding attaining local SDGs.

Besides that, cities and municipalities should evaluate their own policies and regulations and assess what changes and amendments need to be made so that the objectives can be attained.

Thirdly, cities are often in the role of awareness risers, especially in relation to their own policies, regulations and achievements, so that the local administration can take the function of demonstration agent and inform and make aware citizens of the arising challenges and the innovative solutions put forward to overcome them.

Among the raw materials for communication there is data. At the level of cities or municipalities, data can be produced or used by both, the local companies (B) and local authorities (G), or the citizens and visitors (C). Chiehyeon Lim and others[271] have shown that it is convenient to distinguish four reference cases, depending on whether data originate from local companies and government and are used by them (BG2BG), or used by citizens and visitors (BG2C), or whether they are originating from citizens and visitors and are used by local authorities or enterprises (C2BG), or by citizens and visitors (C2C). The following figure shows these four reference cases.

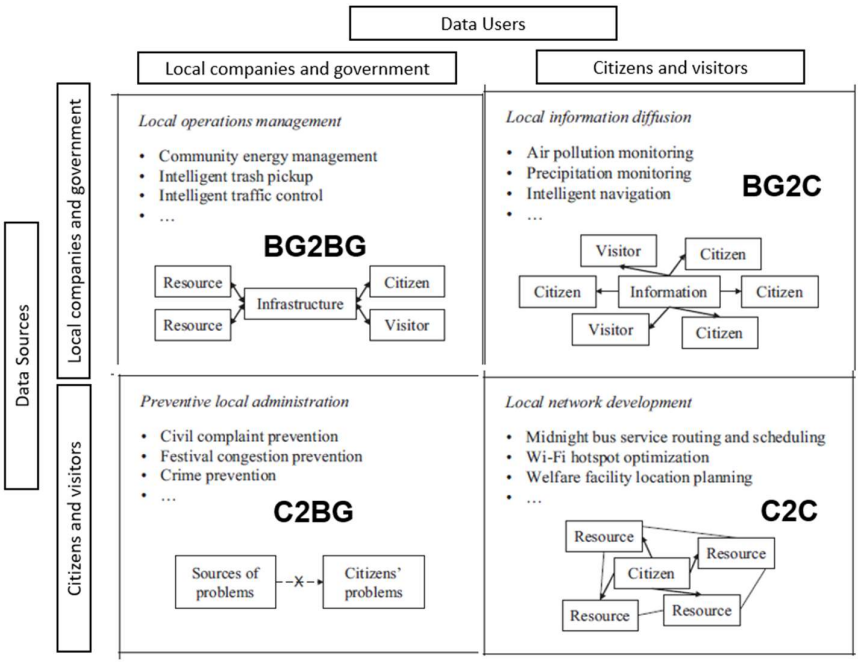

Figure 141: Four reference cases of local data collection and use

Source: APSEC based on an idea of Chiehyeon Lim and others

The Internet of Things (IoT) is said to play an ever-increasing role in collecting data. This may be applicable in the BG2BG case where data is being collected through infrastructures and used by these infrastructures and their managers. IoT may also become an important source of data for the BG2C case where data is collected by infrastructures but destined to citizens and visitors. Local air pollution, local weather forecasts, or road congestion management are the examples cited. However, this reference case includes also all the early warning systems destined to warn the public which is advised or expected to take early preventive or protective action. Such early warning systems concern all disaster types where citizens are advised or required to take early action themselves (extreme weather events, tsunamis, epidemics). Not all disaster types are sufficiently well predictable that early warning is feasible. COVID-19 has revealed the extent of (dis-)trust in early warning systems. The *APEC Integrated Urban Planning Report (2021)* reviews the different disaster types and measures of respective disaster resilience.

Besides IoT, the public at large is the data source for the two other reference cases, namely C2BG and C2C. Such data collection can be manual or semi-automatic (scanning a QR code). Likewise, it can be based on physical events or on paper mails but is likely to shift to virtual events in the future. As an example, stakeholder participation in local affairs has traditionally been a physical event, but it can also become virtual, if a specific APP has been made available for that specific purpose.

Collecting and disseminating data in any of the four reference cases is likely to give rise to new IT based services, such as new APPs, and create new service enterprises that use this data and create specific services which they then market in new business models.

Data collection is but the first step in management of cities and municipalities. Once some data has been collected, targets can be elaborated. This is a critical step of local policy making and local planning. Targets are usually set in those areas where cities and municipalities have the respective competences to do so, depending on legislation. The areas in which cities and

municipalities might consider setting targets can be inferred from the SDGs (see also the section Cities as Planners further above). Given specific situations of cities and municipalities, specific local targets should be added as appropriate. One area where cities and municipalities are usually most welcome to set targets is waste management, an area which is mostly left to be dealt with by the local level authorities.

After setting targets, cities and municipalities elaborate procedures for dealing with specific events and situations. Example of a procedure: if heavy rain falls, the city or municipality may start closing certain roads that become inundated with water to prevent people entering these roads unknowingly. Another example: if a high-power transmission line is overloaded and its temperature rises, the responsible operators may cut the line to prevent irreversible damage. As a third example, if cities or municipalities see that their emissions are off track, they call for a stakeholder dialogue to identify possible measures.

Figure 142: Three elements of data and targets-based management

Source: APSEC

Finally, evaluation of measures is done after the end of the implementation period. SDGs and their indicators are measurable, hence quantitative evaluation is part of the basic design. Evaluation is sufficiently important to the 2030 Agenda that, in December 2014, the UN General Assembly has adopted a specific resolution on evaluation (*A/RES/69/237 - Capacity building for the evaluation of development activities at the country level*), to improve capacity building for evaluation. A progress report has been published in 2022[272]. This report still addresses in priority central governments, whereas cities and local governments are not yet its key focus. But the report makes it clear that all levels of government should demand for evaluation of the policies and measures they implement, that they should put in place the appropriate institutional structure and budgets and improve the capacity of local specialists to do the evaluation. Evaluation is a key element of the theory of change that should be used at all levels of government. The theory of change states that decision-making should be based on timely and credible evidence, either statistics or monitoring reports, and that public and private stakeholders should exchange knowledge around the evaluation agenda.

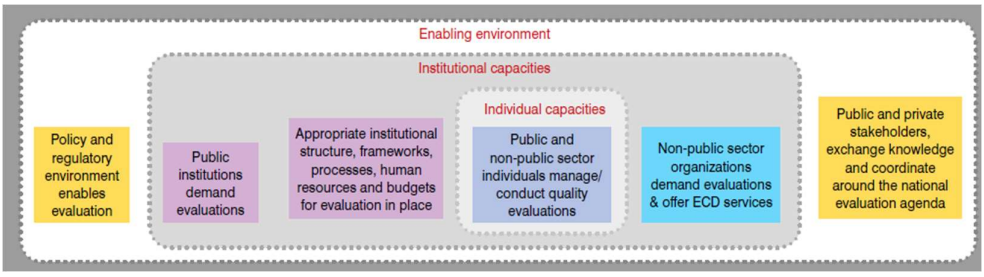

Figure 143: Elements of the data-based theory of change

Source: United Nations[273]

Modern urban planning requires supplementing simple land zoning with more complex and integrated urban planning which should rely on data and be science-based. Concerning data, cities are more involved in data-gathering and in data use than rural municipalities. A rural-urban divide should be avoided. Even small and medium sized towns should be empowered to participate in the data collection and use. The SDGs, their targets and indicators[274], as well as the Disaster Resilience Scorecard for Cities[275] offer a window of opportunity to broaden data-driven planning for all local communities. This is being facilitated by a higher degree of harmonization of collected SDG data across the globe.

If a city or municipality wants to know possible pathways within this framework, it suffices to collect data which are used to compute the local equivalents of three SDG indicators, namely 7.3.1, 8.1.1, and 9.4.1 (see table). For this reason, these three indicators can be called the three essential SDG indicators for the Race to Zero. The objective should be for cities and municipalities of all sizes to collect this data. The up-to-date original definition of these indicators in the different UN languages can be seen on the relevant website of the UN[276] and in the corresponding metadata repository[277].

SDG indicator	Local equivalent indicator
7.3.1	Primary energy intensity of GDP
8.1.1	Annual growth rate of real GDP per capita
9.4.1	CO_2 emission per unit of value added

Table 20: The three essential SDG indicators

Source: APSEC

To establish a link to urban land planning, the above data should be related also to the total land area of the city or municipality. Usually, total land area is constant over time, except in case of changes to the administrative boundaries of the city or municipality. Linking the above data to land allows making an interface to geographical information systems (GIS)[278] and beyond that, to satellite-based observation systems, which widen the scope and accelerate the speed of available data. With the increase of geo-observation, the quantity of available data is not a problem anymore as the quantity of unused satellite data increases year-on-year, but the skills and software to use it becomes the focus. Addressing this issue, Geoscience Australia launched the first Open Data Cube (OCD)[279][280] in 2017, making data available in a user-ready format on open-source software (Python, GitHub). This is a promising way for cities and for towns and smaller municipalities to deepen their sustainability analysis and work out data-based pathways towards carbon neutrality.

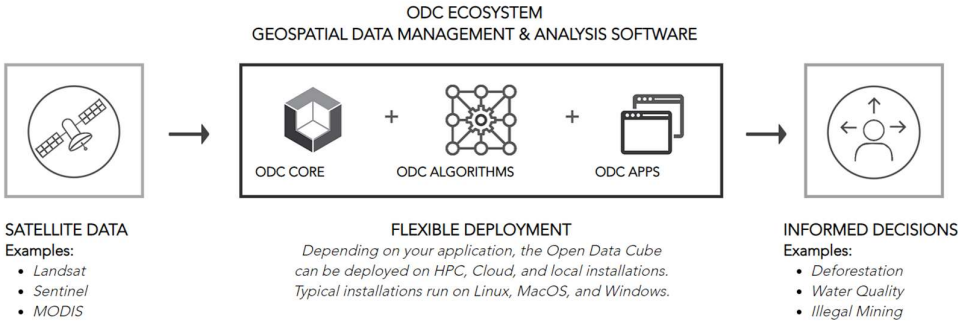

Figure 144: Open Data Cube Ecosystem using open-source software

Source: Opendatacube.org

An Australian project analysed the current and future value of earth and marine observing to the Asia-Pacific region[281]. A follow up APEC project provides for building regional capacity and knowledge in earth observations using data cube technology by setting up an open data cube in Chile[282].

Besides linking the above-mentioned SDG-relevant basic data of cities to their land and to geoinformation systems, extensive thoughts have been made in the *APEC Integrated Urban Planning Report*[283] on what other local equivalents of SDG and disaster resilience data should be made available by local governments for their own use. As the race to zero is largely determined by the global energy system, priority is given to measuring all the targets and indicators of SDG 7 (ensure access to affordable, reliable, sustainable and modern energy for all). As SDG 7 calls for the fossil fuel sector to be replaced by a clean energy sector, it is necessary to also monitor the development of the clean energy sector to the extent this is covered by SDG goals, targets or indicators. Furthermore, the use of broadband internet as well as mobile internet are crucial indicators.

SDG	Local equivalent indicator
7.1.1	% population having access to electricity
7.1.2	% population with primary reliance on clean fuels and technology
7.2.1	% renewable energy in local total final energy consumption
7.b.1	Installed renewable energy-generating capacity
9.2.1	% manufacturing value added local GDP and per capita
9.2.2	% manufacturing employment of total local employment
9.3.1	% small-scale industries in total industry value added
9.5.2	researchers (in full-time equivalent) per million inhabitants
9.b.1	% medium and high-tech industry value added in value added
9.c.1	Proportion of population covered by a mobile network, by technology
17.6.2	Fixed Internet broadband subscriptions per 100 inhabitants
17.8.1	Proportion of individuals using the Internet

Table 21: Further SDG indicators for monitoring the Race to Zero

Source: APSEC

While some regions need to focus on refurbishment of existing buildings, half of the global buildings of 2050 have not yet been built. This illustrates the importance of planning in advance how to shape future cities. Emissions should be disaggregated along their scope[284]: scope 1 (emitted within the territory of the city as a result of activities taking place within the city), scope 2 (emissions occurring outside the city as a result of the use of grid-supplied electricity, heat, steam and/or cooling supplied into the city), and scope 3 (all other emissions occurring outside the city as a result of activities taking place within the city, which includes emissions embodied in goods imported into the city).

The most important contribution to carbon neutrality comes from renewable energy, either generated from within the city (scope 1, distributed renewables, rooftop or building-integrated PV or urban wind turbines) or from outside the city (scope 2, centralized renewables, large wind or solar parks). Energy master planning might set a dynamic target for renewables share which can then be gradually increased until mid-century. A renewables' share can also be declared as compulsory for all new buildings. Such a measure obliges developers to plan for heat pumps to supply heating and cooling in new buildings and for phasing out fossil heating in existing buildings.

SDGs also cover specifically cities and human settlements; SDG 11 is specifically addressing this topic. Integrated urban planning cannot ignore these indicators. SDGs are, however, addressing the level of central government. This means that some of these indicators (e.g., 11.3.2, 11.a.1, 11.a.2) must be adapted to cities to be used at city-level. This has been done in the table below.

SDG	Local equivalent indicators of SDG 11, Sustainable Cities and Communities
11.1.1	% urban population living in slums
11.2.1	% population having convenient access to public transport
11.3.1	Ratio of local land consumption rate to local population growth rate
11.3.2	Whether the city has participation structure for urban planning
11.4.1	Expenditure per capita spent on cultural and natural heritage
11.5.1	Persons directly affected by disasters per 100,000
11.5.2	Direct local economic loss attributed to disasters in % GDP
11.6.1	% urban solid waste regularly collected
11.6.2	Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10)
11.7.1	% of built-up area of cities open space for public use
11.7.2	% victims of physical or sexual harassment in previous 12 months
11.a.1	Whether the city implements plans integrating population projections
11.b.2	Whether the local government implements local DRR strategies

Table 22: Local equivalent indicators of SDG 11, sustainable cities and human settlements

Source: APSEC

Several of these indicators refer to disaster resilience. The specialised UN framework for disaster resilience is called Sendai framework for disaster risk reduction 2015[285]. The derived city-level document is the Disaster Resilience Scorecard for Cities. It exists in two variants, one for a preliminary assessment and the other for a detailed assessment. The preliminary assessment considers basically a simplified indicator list defined by a two-digit hierarchy, whereas the detailed assessment uses full 3-digit definition of indicators. For simplification we only use the full detailed scorecard[286]. The adoption and worldwide dissemination of SDGs and their targets and indicators may help improving sustainability planning in cities. The Race to Zero might come too late for some cities, especially those which are in areas struck by natural disasters. To fight the future intensity and frequency of disasters caused from climate change, cities must increasingly plan for disaster resilience. The *APEC Integrated Urban Planning Report – Combining Disaster Resilience with Sustainability*[287] analyses what this means for cities. It concludes that disaster resilience is the instrument to attain sustainable development at city level. For this reason, disaster resilience for cities and local communities should become the twin of localized SDG targets and indicators.

The SDGs identify many targets and indicators related to water and wastewater. Water and wastewater are basic services and, thus, covered by 1.4.1, proportion of the population with access to basic services. 3.9.2 monitors the mortality rate by unsafe water services and hygiene (WASH), 6.1.1. the percentage of population using safe drinking water, 6.3.1. the proportion of wastewater safely treated, 6.5.1. the degree of integrated water resources management, and 6.b.1 whether the community participates in water and sanitation management. These indicators are included in the urban SDG tracker proposed for APEC cities and communities.

Techno parks have been described in the previous section as breeding hubs for technology-oriented SMEs. They contribute to avoid deindustrialization and to create tomorrow's high or medium tech manufacturing industry (SDG indicators 9.2.1, 9.2.2, 9.3.1, 9.b.1). Information systems are indispensable today; the four mentioned systems (banks & insurances, geographic information systems GIS, open data cubes ODC, and land registries) are but a selection. Insurances include unemployment insurance; unemployment is monitored in SDG 8.5.2. SDG 1.4.2 monitors the proportion of adult population having secure tenure rights to land. Affordable housing has been described in the previous section as essential to guarantee financial viability of TOD systems. For increasing participation in urban affairs, SDG 5.5.1 monitors the proportion of women in local assemblies, and 16.7.1 can be translated to the urban context to mean the proportion of young (<45 years) members of local assemblies. Application of the criminal laws is monitored by 11.7.2 (victims of harassment) and 16.1.1. (homicides per 100'000 inhabitants).

The additions in the natural infrastructures are mostly conditioned by the role such infrastructures have in disaster resilience. This is very well described in the Disaster Resilience Scorecard for Cities. Essential 5 is about safeguarding natural buffers to enhance the protective functions offered by natural ecosystems. Ecosystem services should be specifically identified and managed as critical assets. Green and blue infrastructure should be routinely embedded into projects across the city – in new urban development, regeneration and infrastructure projects. Even though urban disaster resilience is improving, it should be emphasized that cities usually cannot sufficiently contribute to their long-term food sustainability, which is essentially dependent on the city's agricultural hinterland. Cities could possibly make a small contribution to protect endangered local breeds by creating agricultural

research institutes mandated to monitor SDG indicator 2.5.2. The table below lists the key SDG indicators that specifically address local communities, as well as those indicators which cities can influence through management of one of their infrastructures.

SDG	Local equivalent indicators specifically destined to local communities
2.5.2	For rural communities: % local breeds classified as being at risk
5.5.1	% of seats held by women in local legislative/deliberative assembly
6.b.1	Whether local communities participate in water and sanitation management
16.7.1	% of young members < 45 years old in local legislative/deliberative assembly
SDG	Local equivalent indicators linked to management of local infrastructures
1.4.1	% population with access to basic services
1.4.2	% adult population with secure tenure rights to land
3.9.2	Mortality rate by unsafe WASH
3.9.3	Mortality rate by unintentional poisoning
4.1.1	% children by category with reading or math proficiency
4.4.1	% youth with ICT skills
6.1.1	% population using safe drinking water
6.3.1	% wastewater safely treated
6.5.1	Degree of integrated water resources management
8.5.2	Unemployment rate by category
9.1.1	% rural population with access to all-season road
10.4.1	Labour share of GDP
12.4.2	Generation of hazardous waste and % treated
12.5.1	waste recycling (tons)
14.1.1	Index of local coastal eutrophication
15.1.1	Forest cover ratio of total land
16.1.1	Homicides per 100'000 by sub-category

Table 23: Local equivalent indicators that cities can manage by their infrastructures

Source: APSEC

4. Key Conclusions and Recommendations

Key Conclusions

The following key conclusions can be drawn from this report:

Technically, the 1.5-degree goal can still be reached, but only a narrow pathway with around 400 milestones can lead to this goal.

The global investment gap is huge; the world should quadruple global annual investment in energy and direct most of it to clean energy.

Investment towards emerging and developing economies should undergo a six-fold increase. If this happens, huge benefit can be expected as costs of reducing carbon emissions in developing and emerging economies are less than half of costs in advanced economies.

Decent Living Standards (DLS) require around 500W per capita, including 120W in form of food energy. With a global capacity factor of renewable electricity expected to drop from today 30% to 20%, DLS require installed renewable electricity of 1900W per capita plus 120W in form of food energy.

Green finance can play a crucial role to reach carbon neutrality if it develops rapidly and at scale.

Green finance is defined as finance allocated to the green sector economy. Taxonomies of green sector economy are adequate instruments to clearly define the green sector and avoid greenwashing. ESG may not be able to avoid greenwashing.

To increase the volume of green finance, measures exist to 1) increase the returns and profitability and 2) diminish the risks of green investments.

Economic instruments are essential to increase the returns and profitability of green investments. Setting a carbon price by means of a carbon tax at international scale is difficult in the impossibility – due to WTO rules – to set border tax protection against carbon leakage. Modest local carbon taxes as they exist in specific markets in some APEC cities are however a useful means to create local green finance.

Emission trading scheme (ETS) or carbon certificate trading is the least cost option for developing towards carbon neutrality. Its advantages are all the greater the more ETS markets are coupled together. ETS can be accompanied by a Carbon Border Adjustment Mechanism (CABM) which is compatible with WTO rules. Based on the agreement reached at COP26, ETS and trade in renewable energy certificates (REC) or green certificates can be merged in compliance markets. If cities receive mandatory emissions targets, they should be allowed to participate in compliance markets. Cities are creating voluntary carbon markets, especially for maintaining and increasing forests. Voluntary markets can be subject of greenwashing if they are not sufficiently monitored.

Fossil fuel subsidies are four times larger than subsidies to renewables at global scale.

Feed-in tariffs (FIT) have proven to bring about the most rapid increase of renewables. Some APEC cities have made good experiences with local FIT. Local FIT together with Power

Purchase Agreements (PPA) are instruments of choice for cities to increase the local per capita installed renewable electricity capacity.

Green bonds are the most rapidly developing green finance instrument. Some cities (Manila) propose that cities should develop the use of green bonds.

Green loans are mostly granted by IFC.

Green equity is a way to have more finance and less debt.

Green guarantee schemes are the most important de-risking tool. They work similarly to insurance. The world is still waiting for a global de-risking guarantee announced by the International Solar Alliance in 2018.

Cat bonds are a form of environmental (re-)insurance transferring disaster risks to the market.

A catalytic factor of 8 has been described in a GCF project implemented the Beijing-Tianjin-Hebei area.

Recommendations

This report outlines roadmaps towards global carbon neutrality, shows how green finance can close the financing gap, and describes how cities can catalyse the energy transition according to their multiple roles.

Based on this report, the following specific recommendations are made.

APEC should set the goal to double the per capita installed renewable electricity capacity by 2030 and reach the 2000W/person threshold in 2035. An agreement with IRENA might be appropriate for realizing this goal.

APEC should consider setting carbon-neutrality as a collective long-term goal to be attained by 2050 for developed economies and by 2060 for developing economies.

APEC should consider redefining the principle of phasing out fossil fuel subsidies decided in 2009. APEC should consider formulating a principle stating that part of fossil fuel subsidies should be phased out, whereas another part should be redirected towards renewable energies, especially for poor and vulnerable populations.

APEC should consider setting up mechanisms to increase both, public and private green investment, especially in developing economies. Green investment should comprise more equity than debt. APEC cities should be active in shaping the local regulatory environment so that green equity develops easier on their territory.

APEC should explore whether APEC cities can set minimum values for the catalytic factor of public investment in the green economy in their cities.

Specifically, APEC should consider the feasibility of setting up, possibly with the participation of APEC cities, an APEC-wide de-risking guarantee scheme for renewable energy.

Annex 1: Lists of APEC Projects

List 1 of the 41 APEC EWG Projects relating to Low Carbon Model Towns (LCMT)

Project Number	APEC EWG projects related to LCMT	Economy
EWG 09 2010A	APEC Low-Carbon Model Town (LCMT) Project, Phase 1	United States
EWG 06 2011A	APEC Low-Carbon Model Town (LCMT) Forum	Malaysia
EWG 18 2011A	APEC Low Carbon Model Town (LCMT), Phase 2	Korea
EWG 08 2011A	Increasing Foreign Direct Investment Through Human Capital Development in the Area of Green Township / Eco-City that would lead to Sustainable Development within APEC Economies	Malaysia
EWG 11 2012A	The Comprehensive Analysis and Research of Key Technologies and Commercial Model of Low Carbon Model Town Applied in Yujiapu CBD	China
EWG 10 2012A	Establishing Low Carbon Energy Indicators for Energy Strategy Study in APEC Low Carbon Town	China
EWG 20 2012A	APEC Low Carbon Model Town (LCMT) Project Phase 3	United States
EWG 18 2012A	APEC Peer Review on Low-carbon Energy Policies (PRLCE) Phase 2	Japan
EWG 24 2013A	District Energy Systems Development Roadmap Study in APEC Economies	China
EWG 10 2013A	APEC Low Carbon Model Town (LCMT) Promotion through Eco-Point Program (LCMT-EPP)	Thailand
EWG 25 2013A	APEC Low Carbon Model Town Heating System Application Model and Best Practices	China
EWG 20 2013A	APEC Low Carbon Model Town Energy Management System Development and Application Research	China
EWG 21 2013A	Study of APEC Low Carbon Model Town Development Index System	China
EWG 18 2013A	APEC Low Carbon Model Town (LCMT) Project, Phase 4	Japan
EWG 05 2013A	APEC Low Carbon Model Town Capacity Building Development (LCMT-CBD)	China
EWG 13 2013A	APEC Low-Carbon Model Town Development Model and Tool Kit Study (LCMT-DMTK)	China
EWG 01 2014A	APEC Peer Review on Low-Carbon Energy Policies (PRLCE), Phase 3	Japan
EWG 06 2014A	APEC Low Carbon Model Town (LCMT) Project, Phase 5	United States
EWG 07 2014A	Realization of APEC Low Carbon Model Town through Smart Grid Development (LCMT-SGD)	Thailand
EWG 02 2015A	APEC Nearly (Net) Zero Energy Building Best Practices and Energy Reduction Results Comparative Study	China
EWG 09 2015A	Workshop on Improving Energy Resiliency in Off-Grid Areas in APEC Member Economies	Philippines
EWG 01 2015A	APEC Low-Carbon Model Town (LCMT) Project - Phase 6	United States
EWG 11 2015A	APEC Low Carbon Model Town Solar Photovoltaic Agricultural Development Mode Study	China
EWG 07 2015S	Workshop on the Establishment of a Cooperative Network of Sustainable Cities (CNSC) in APEC Economies	China
EWG 10 2015A	Capacity Building on Strategies and Implementation of Low-Carbon Town in APEC Economies	China
EWG 03 2016A	Study on the Cost-Effective Renewable Energy-Supply Solutions based on Innovative Solar Technologies to Promote Green Buildings in APEC Region	China
EWG 02 2016A	APEC Low-Carbon Model Town (LCMT) Project, Phase 7	Japan
EWG 06 2016A	Experience Sharing Workshop on the Five Years Construction of the First Low Carbon Model Town (LCMT) —Yujiapu CBD	China
EWG 15 2016A	APEC Nearly (Net) Zero Energy Building Roadmap Study Responding to COP21	China
EWG 01 2017A	APEC Peer Review on Low-Carbon Energy Policies (PRLCE), Phase 4	Japan
EWG 03 2017A	APEC Low-Carbon Model Town (LCMT) Project Dissemination, Phase 1	Japan
EWG 13 2017A	Integrated Energy System Planning for Equitable Access to Sustainable Energy for Remote Communities in the APEC Regions using North Sulawesi as a Pilot Project/Test Bed	Australia
EWG 01 2018A	APEC Low-Carbon Model Town (LCMT) Project Dissemination Phase 2	Japan
EWG 06 2018A	APEC Workshop on Energy and Economic Prosperity	Viet Nam
EWG 09 2018A	APEC Best Practice Guidelines for Establishing and Enhancing Energy Efficiency Incentive (EEI) Schemes	Australia

EWG 14 2018A	Coordinating Standards for Cool Roof Testing and Performance	United States
EWG 04 2019A	Exploring Co-Benefit Opportunities for Renewable Energy and Energy Efficiency Projects in the APEC Region	Thailand
EWG 01 2019A	APEC Low-Carbon Model Town (LCMT) Project Dissemination Phase 3 (hereinafter referred to as Dissemination Phase 3)	Japan
EWG 11 2019A	Accommodating Disruptive Technology into Renewable Energy and Energy Efficiency (RE & EE) Policies for Energy Security	Thailand
EWG 07 2020A	Workshop on Energy Resilience Principle	Japan
EWG 11 2020A	Implementation of Low-Carbon Model Town through Green Building Infrastructure and Management Platform	Indonesia

List 2 of the 48 APEC EWG Projects related to Urban Topics other than LCMT

Project Number	APEC EWG projects related to urban topics other than LCMT	Economy
EWG 01 2006A	The Future of Liquid Biofuels for APEC Economies	Thailand
EWG 03 2007A	Survey of Transport Efficiency Policies in APEC Economies	United States
EWG 01 2007A	Survey of Biomass resource Assessments and Assessment capabilities in APEC Economies	United States
EWG 11 2008A	Assessment of Biomass Resources from Marginal Lands in APEC Economies	United States
EWG 02 2008A	Workshop on Policies to Promote Energy Efficiency in Transport in APEC Economies	United States
EWG 04 2008	APEC 21st Century Renewable Energy Development Initiative (Collaborative VI): Best Practices in New and Renewable Energy Technologies in Urban Areas in the APEC Region	United States
EWG 11 2009A	Cool Roofs in APEC Economies: Review of Experience, Best Practices and Potential Benefits	United States
EWG 04 2009	Overview of APEC Energy Working Group Projects - Stage 3	Australia
EWG 18 2009	Resource Potential of Algae for Biodiesel Production in APEC Economies	United States
EWG 20 2009	Biofuel Transport and Distribution Options for APEC Economies	United States
EWG 08 2010A	Street and Outdoor LED Lighting Initiative - Asia (SOLLIA)	United States
EWG 13 2011A	Workshop on Low Emission Development Strategies (LEDS) for APEC Economies with a Focus on Energy and Transport	United States
EWG 20 2011A	Archiving Low-Carbon Development in APEC's Communities by Using Higher-Efficiency and Cleaner Gas-Fired Cogeneration Technology	China
EWG 05 2011A	APEC Workshop on Energy and Green Transport Benefits of Electric Vehicles	Hong Kong, China
EWG 19 2011A	Best Practices in Energy Efficiency and Renewable Energy Technology in the Industrial Sector in APEC	Thailand
EWG 17 2011A	Promotion of Energy Efficiency and Renewable Energy in Low Carbon Model Town of APEC through Distributed Energy Source - Identification of Potential Challenges and Solutions	China
EWG 09 2011A	Renewable Energy Sources in Electricity Markets: Goals and Conditions for Providing Sustainable Development	Russia
EWG 11 2011	APEC 21st Century Renewable Energy Development Initiative (Collaborative IX): Stock-take of Electric Vehicle Interface with Electricity and Smart Grids across APEC Economies and the Potential for Harmonisation	New Zealand
EWG 08 2012	Urban Development Smart Grid Roadmap - Christchurch Recovery Project	New Zealand
EWG 01 2012A	APEC Cooperative Energy Efficiency Design for Sustainability (CEEDS), Phase 4	Japan
EWG 16 2012A	Research on the Application of Physical Energy Storage Technology with Renewable Energy in a Low Carbon Town	China
EWG 24 2012A	Operation Technology of Solar Photovoltaic Power Station Roof and Policy Framework	China
EWG 23 2012A	Study on Measures to Reduce Energy Intensity in APEC Low Carbon Town	China
EWG 04 2013A	Transportation and Low Emissions Development Strategies Workshop	United States
EWG 06 2013A	APEC Smart DC Community Power Opportunity Assessment	Thailand
EWG 11 2013A	APEC Photovoltaic Application Roadmap and Model Study (PVARM)	China
EWG 03 2013A	Building Code Harmonization in Energy Smart Community	China

EWG 03 2014S	Clean and Efficient Use of Energy and Water Resources - Initiating an APEC Road Map and Best Practices for the Energy-Water Nexus	United States
EWG 08 2014A	Water-Energy Nexus: Coal-Based Power Generation and Conversion - Saving Water	United States
EWG 22 2015A	Developing Solar-Powered Emergency Shelter Solutions (SPESS) as an Energy-Resilience Tool for Natural Disaster Relief in APEC Community	China
EWG 18 2015A	A Comparative Study on Multi-Field Applications of Building-Mounted Photovoltaic (BMPV) in the APEC Region	China
EWG 06 2015A	Establishing Lighting Best Practices and Educational Programs to Achieve Deep Energy Saving, An APEC Regional Collaboration with University Lighting Centers and Research Institutions	United States
EWG 12 2015A	Ethanol Trade Development as Part of APEC's Renewable Fuel Strategy	United States
EWG 07 2015A	APEC Water-Energy Nexus Expert Workshop	United States
EWG 09 2016A	Promoting Innovative Green Financing Mechanisms for Sustainable Urbanization and Quality Infrastructure Development in APEC Region	China
EWG 04 2016A	Research on Energy Storage Technologies to Build Sustainable Energy Systems in the APEC Region	China
EWG 14 2016A	Incubator for Enhancing Commercial Buildings Energy Performance	Australia
EWG 13 2016A	Supporting the Development and Implementation of Low-Emission Development Strategies (LEDS) in Transport Sector	United States
EWG 10 2018A	Low Emissions Development Strategies: Supporting the Transition to Energy Efficient, Electric Transport Systems	United States
EWG 11 2018S	Research on Effective Strategies for Overcoming the APEC Sustainable Urbanization Gaps	China
EWG 05 2019A	Sustainable Mobility: Routes for Integrating the Energy and Transport Sectors for Urban Cities	United States
EWG 09 2019S	Research on the Role of Urban Planning for Addressing Climate Change and Disasters	China
EWG 08 2019A	Energy Intensity Reduction in the APEC Regions' Urbanised Cities	Hong Kong, China
EWG 04 2020A	A Community-based Waste Management to Renewable Energy Workshop	Indonesia
EWG 14 2020A	The Promotion of Community Waste-to-Energy System	Chinese Taipei
EWG 04 2021S	Research on Means to Overcome Shortage of Basic Urban Energy-Climate Data	China
EWG 09 2021S	Research on Means to Diminish the Financing Gap for Sustainable Urban Energy	China
EWG 12 2021A	APEC Workshop Furthering University Collaboration to Support Data Gathering and Analysis in Energy Efficiency, Renewable Energy, and Energy Resiliency	United States

List 3 of the 33 APEC Projects combining focus of both, waste and urban matters

Number	Project title	Economy
EWG 20 2009	Biofuel Transport and Distribution Options for APEC Economies	United States
IST 04 2010	APEC International Biogas Resources Development and Utilization Science and Technology Cooperation Forum	China
EWG 20 2011A	Archiving Low-Carbon Development in APEC's Communities by Using Higher-Efficiency and Cleaner Gas-Fired Cogeneration Technology	China
EWG 18 2011A	APEC Low Carbon Model Town (LCMT), Phase 2	Korea
EWG 19 2011A	Best Practices in Energy Efficiency and Renewable Energy Technology in the Industrial Sector in APEC	Thailand
EWG 17 2011A	Promotion of Energy Efficiency and Renewable Energy in Low Carbon Model Town of APEC through Distributed Energy Source - Identification of Potential Challenges and Solutions	China

EWG 16 2012A	Research on the Application of Physical Energy Storage Technology with Renewable Energy in a Low Carbon Town	China
EWG 20 2012A	APEC Low Carbon Model Town (LCMT) Project Phase 3	United States
EWG 23 2012A	Study on Measures to Reduce Energy Intensity in APEC Low Carbon Town	China
EWG 24 2013A	District Energy Systems Development Roadmap Study in APEC Economies	China
PPSTI 05 2013A	APEC Smart City Innovation & Technology Cooperation Forum	China
EWG 25 2013A	APEC Low Carbon Model Town Heating System Application Model and Best Practices	China
EWG 18 2013A	APEC Low Carbon Model Town (LCMT) Project, Phase 4	Japan
EWG 06 2014A	APEC Low Carbon Model Town (LCMT) Project, Phase 5	United States
EWG 01 2015A	APEC Low-Carbon Model Town (LCMT) Project - Phase 6	United States
EWG 10 2015A	Capacity Building on Strategies and Implementation of Low-Carbon Town in APEC Economies	China
PPFS 02 2016	Challenges for Water and Food Security, in a Context of Climate Change in the APEC Region	Peru
EWG 02 2016A	APEC Low-Carbon Model Town (LCMT) Project, Phase 7	Japan
CTI 08 2017A	Best Practices Sharing of Standards and Conformity Assessment Implementation on Smart Cities in APEC Region	Viet Nam
EWG 03 2017A	APEC Low-Carbon Model Town (LCMT) Project Dissemination, Phase 1	Japan
EWG 13 2017A	Integrated Energy System Planning for Equitable Access to Sustainable Energy for Remote Communities in the APEC Regions using North Sulawesi as a Pilot Project/Test Bed	Australia
CTI 07 2018A	Best Practices on Circular Economy: Redefining Growth: From Waste to Worth	Mexico
EWG 01 2018A	APEC Low-Carbon Model Town (LCMT) Project Dissemination Phase 2	Japan
PPFS 04 2018	Efficient and Sustainable Use of Water for Agriculture under the New Climate Scenarios as a Contribution to Food Security	Chile
OFWG 01 2018A	Update of 2009 APEC Report on Economic Costs of Marine Debris to APEC Economies	United States
EWG 01 2019A	APEC Low-Carbon Model Town (LCMT) Project Dissemination Phase 3 (hereinafter referred to as Dissemination Phase 3)	Japan
SCE 01 2019	Initiative for Realising Sustainable Cities Focusing on Improvement of Resource Circulation and Waste Management	Japan
ATC 01 2020	APEC Workshop on the R&D and Promotion of Smart Agriculture	Chinese Taipei
EWG 04 2020A	A Community-based Waste Management to Renewable Energy Workshop	Indonesia

SCSC 03 2020A	13th SCSC Conference: Standardisation in Circular Economy for a more Sustainable Trade	Malaysia
EWG 14 2020A	The Promotion of Community Waste-to-Energy System	Chinese Taipei
ATC 02 2020A	APEC Workshop on Practices and Promotion of Circular Agriculture	Chinese Taipei
OFWG 08 2020A	Enhancing Collection and Segregation of Waste to Reduce Marine Litter in APEC Economies	United States

List 4 of the 11 APEC projects touching on wastewater. Except for the last project of this list, all projects also have a relation to energy

Number	Project title	Economy
CTI 30 2008T	Environmental Goods and Services (Climate Change) One Day Workshop	New Zealand
EWG 12 2009A	Energy and Water Efficiency in Water Supply - Practical Training on Proven Approaches	United States
IST 01 2009A	Utilization and Protection of Water Resources	China
EWG 18 2009	Resource Potential of Algae for Biodiesel Production in APEC Economies	United States
IST 04 2010	APEC International Biogas Resources Development and Utilization Science and Technology Cooperation Forum	China
IST 03 2012A	Low Carbon Intelligent Operations for Textile Industry in APEC Economies	Chinese Taipei
EWG 25 2012A	Enhance Energy Utilization and Transformation Efficiency through Comprehensive Utilization of Coal	China
EWG 25 2015A	Strategy for Large-Scale Implementation of Biogas Capture from Palm Oil Mill Effluent and Reuse for Renewable Electricity Generation	United States
HRD 02 2017A	Promoting Regional Connectivity of Professionally Qualified Engineers in APEC	Singapore
PPSTI 02 2017A	APEC Research Center for Advanced Biohydrogen Technology (ACABT) - Smart Power Management for Self-Sustained Green Community in APEC Region	Chinese Taipei
EWG 13 2018A	APEC Workshop on Integrated Energy-Water Planning and Policy Formulation	United States
SCSC 03 2019T	Capacity Building on Testing and Conformity Assessment of Fine Bubble Technologies for Use in Agro-/Aqua-Culture and Water Treatment in the APEC Region	Japan

Annex 2: List of initiatives of the Climate Ambition Alliance

Source: Global Climate Action portal (https://climateaction.unfccc.int/)

100 water and climate projects for Africa

2050 Pathways Platform

4/1000 Initiative - Soils for Food Security and Climate

Action towards Climate-Friendly Transport (ACT)

Adaptation for Small holder Agriculture Programme (ASAP)

Adaptation of West African Coastal Areas (WACA)

Africa Renewable Energy Initiative (AREI)

African Adaptation Initiative (AAI)

Airport Carbon Accreditation

Ambitious SIDS Climate Action

Assessing low-Carbon Transition (ACT)

Below50

Blue Growth Initiative

Bonn Challenge

Breakthrough Energy Coalition

Building Climate Resilience for the Urban Poor

Business Ambition for 1.5°C

C40 Clean Bus Declaration/Low emission vehicles

C40 Zero Waste Declaration

Carbon Neutral Cities Alliance (CNCA)

Caring for Climate

CCAC: Global Green Freight Action Plan

CCAC: Oil & Gas Methane Partnership (OGMP)

CCAC: Phasing Down Climate Potent HFCs / HFCs Initiative

CCAC: Waste, Mitigating SLCPs from the Municipal Solid Waste Sector

CEM: Global Lighting Challenge

Central African Forests Initiative (CAFI)

Central American Integration System Initiative (SICA)

Cities and Regions' 5-year vision

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Clean Air Initiative

Clean Cooking Fund

Clean Energy Corridors in Africa

Climate Action 100+

Climate Action for Jobs Initiative

Climate Ambition Alliance

Climate Ambition Alliance: Net Zero 2050

Climate Ambition Alliance: Race to Zero

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Climate Neutral Now

Climate Risk and Early Warning Systems Initiative (CREWS)

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Climate-Smart Agriculture Booster (CSA Booster)

Coalition for Climate Resilient Investment (CCRI)

Coalition for Sustainable Energy Access (CSEA)

Coalition of Finance Ministers for Climate Action

Collaborative Climate Action Across the Air Transport World

Compact of Mayors

Conference of Peripheral Maritime Regions

Cool Coalition

Covenant of Mayors for Climate & Energy

Debt Swap

District Energy Accelerator

DivestInvest

EcoMobility Alliance

Energy Storage Initiative

EP100

EV100

Fashion Industry Charter for Climate Action

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Getting to Zero Coalition (GtZ Coalition)

Global Alliance for Buildings and Construction (GlobalABC)

Global Alliance for Clean Cookstoves

Global Campaign for Nature

Global Covenant of Mayors for Climate & Energy

Global Energy Efficiency Accelerator Platform (SE4All)

Global Fuel Economy Initiative (GFEI)

Global Geothermal Alliance (GGA)

Global Initiative on Food Loss and Waste Reduction – SAVE FOOD

Global Lead City Network on Sustainable Procurement (GLCN)

Global Resilience Partnership (GRP)

Governors' Climate and Forests Task Force (GCF)

Great Green Wall for Sahara and the Sahel Initiative (GGWSSI)

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Oil and Gas Climate Initiative (OGCI)

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Green Finance Report

Unlocking the Urban Energy Transition

Asia-Pacific Economic Cooperation

APEC Sustainable Energy Center

Carbon neutrality has become a widely discussed long-term goal. While it is a pathway to prosperity, not to austerity, it does not come without investment. Most APEC economies are considering ways to become carbon neutral by mid-century, but only thirteen APEC cities are clearly committed to this target. Access to finance remains their greatest challenge on this pathway.

This report outlines roadmaps towards global carbon neutrality, shows how green finance can close the financing gap, and describes how cities can catalyse the energy transition according to their multiple roles.

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