IMPROVING THE AVAILABILITY AND USEFULNESS OF PUBLICLY AVAILABLE ENVIRONMENTAL DATA FOR FINANCIAL ANALYSIS

In support of the G20 Green Finance Study Group

July 2017

This background paper has been prepared for the G20 Green Finance Study Group (GFSG) by specialists from the Green Finance Committee of the China Society for Finance and Banking, UN Environment Inquiry and the World Resources Institute, with inputs from 2 Degrees Investing Initiative, Amundi, CDP, eRevalue, IPE, PRI, SynTao Green Finance, UBS, University of Cambridge Institute for Sustainability Leadership, University of Hamburg, and Oxford University. The views expressed in this paper are those of the authors and contributors, and do not necessarily represent the views of the GFSG or their institutions.

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1. Context

This background paper provides inputs to the G20 Green Finance Study Group (GFSG) that considers options to improve the availability, accessibility and relevance of publicly available environmental data (PAED) for the financial sector. In this paper, we define PAED as environmental data that are reported by non-corporate entities, such as government agencies, international organizations (IOs), non-governmental organizations (NGOs) and science institutes, and that are useful for financial analysis. The focus of this study on public data is complementary to the subject matter considered by the Financial Stability Board (FSB) Task Force on Climate-related Financial Disclosures (TCFD). The TCFD has already devoted significant resources to studying how to improve corporate-level financial disclosure of climate-related information. The GFSG work stream on PAED will also be complementary to the study group's research on Environmental Risk Analysis (ERA) in 2017, as public data are very important sources of information for financial institutions to conduct risk analysis, in addition to information disclosed by corporates.

This background paper will first provide an overview of the types of environmental data that are critical to green finance analysis, with a focus on public data; it will then present selected examples of existing public data sources that are useful for evaluating financial risks and opportunities; it will analyse the gaps in availability and accessibility of public data and will then conclude with a discussion on options for improving the availability, accessibility and relevance of PAED. It should be noted that the examples of the data sources (including projections and scenarios) quoted in this paper are those of the authors of the original research reports, and do not reflect the views of the GFSG or its members.

2. Why Environmental Data?

Information is an important basis for the financial market to allocate resources. Without proper environmental information, investors, lenders and insurers cannot assess the financial relevance of environmental and climate aspects for their decisions. This can lead to inadequate understanding, pricing and management of environmental risks (see Table 1), and could in turn lead to volatility in asset valuations, including large, non-linear and unexpected impairments. The lack of environmental information also impedes the effectiveness of investors' corporate engagement over material environmental issues.

Table 1: Environmental Risk Matrix

<table>
<tr><td colspan="2"></td><td colspan="4">Financial risks</td></tr>
<tr><td colspan="2"></td><td>Business</td><td>Legal</td><td>Credit</td><td>Market</td></tr>
<tr><td rowspan="2">Environmental sources</td><td>Physical
- Climatic
- Geologic
- Ecosystems</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Transition
- Policy
- Technology
- Sentiment</td><td></td><td></td><td></td><td></td></tr>
</table>

Source: 2016 G20 Green Finance Synthesis Report, GFSG.

Note: In view of the categories of financial risks deriving from environmental sources, we introduced a risk matrix in the 2016 G20 Green Finance Synthesis Report, that the financial risks mainly include business risks, credit risk, market risk and legal risk, while risks deriving from environmental sources include physical risk and transition risk.

The lack of, or difficulty in access to, relevant environmental data also limits the ability of financial decision makers to allocate resources to green investment opportunities that generate competitive risk-adjusted returns. Without proper environmental information, financial decision makers might struggle to assess which companies and projects are green or greener, and whether investment returns from certain green projects will be financially attractive, and are thus unable to effectively allocate capital to green sectors.[1] In addition to investors seeking competitive risk-adjusted returns, a growing number of 'values-based' investors are focusing on the alignment of their funds to long-term policy signals and societal goals, notably the Sustainable Development Goals (SDGs) and the Paris Agreement on climate change. However, this effort may also be challenging without proper environmental data. Some government agencies that intend to provide incentives to green investments may also find it difficult to identify the right recipients for such incentives, when environmental information and the environmental cost/benefit analysis based on it is lacking.

3. Why PAED?

A growing number of financial institutions are recognizing that environmental risks may become material under some circumstances as evidenced by several existing studies.[2] Such an understanding led to the initiation of the TCFD to improve corporate-level disclosure of climate-related information, largely for assessing the "current exposure" of corporates and financial firms to environmental risks (such as the quantity or "footprint" of GHG emissions, and emissions of air and water pollutants). However, in addition to the size of "current exposure", effective risk analysis also requires information on possible future scenarios (or trajectories) of changes in climate and other environmental factors, policy responses and externalities. Such information, most of which is forward-looking in nature, comes largely from public sources including governments, IOs, NGOs and science institutes. Such information can help financial firms and others to assess the probabilities and impacts of physical and transition risks.

If one understands "risk analysis" from the perspective of "managing downside risks" by "avoiding destructive exposures", financial institutions are also engaged in "gaining more exposures" to green investment opportunities or green assets that could deliver environmental benefits. In this regard, PAED is also an important input for identifying and evaluating green financial opportunities. For example, banks, investment funds and insurance companies need to assess the future revenue and cost trajectories when they are making investment decisions on projects or assets in areas such as environmental remediation, energy efficiency, clean energy, sustainable infrastructure and sustainable buildings. Much of the environmental information related to such investment decisions also comes from public sources.

Non-exhaustive examples of useful public data for assessing risks and opportunities arising from environmental trends include:

1. Scenarios of global warming (x degree scenarios) and associated projections on natural disaster probabilities;
2. Forecasts for energy demand shift;
3. Projections of water stress;
4. Costs of air pollution (and benefits of air pollution reduction);
5. Costs of water pollution (and benefits of water pollution reduction);
6. Costs of land contamination (and benefits of land remediation);
7. Data on solar and wind resources;
8. Environmental (e.g., emission) data at facility level; and
9. Information on green technologies.

These PAED provide the essential context for assessing the risks and opportunities at asset or firm level, such as those arising from the change in probabilities of natural disasters, the decline in demand for fossil fuels, the rise in water stress due to global warming and industrial activities, as well as the health, economic and legal costs of air, water and land pollution; demand projections for clean energy and energy efficiency projects; projections on demand for water and water-saving technologies, as well as the environmental benefits of reductions in air, water and land pollution.

Relatively limited availability, accessibility and relevance of PAED have been an obstacle for many financial firms to begin their engagement in green finance activities. Raising awareness of the existence of many public data sources and improving their accessibility and relevance could be a low-hanging fruit for the financial sector. The GFSG can try to improve the connectivity between the science communities producing such data and the financial institutions that have the potential demand for them. There are already pilot examples of how public data can be aggregated and presented for more effective usage by the financial sector, and their lessons can be shared.[3] In addition, as a large part of these data are public goods in nature, there appears to be a need to consolidate, or link, such public environmental information sources into "one-stop shops" (public data platforms) for green finance analysis.

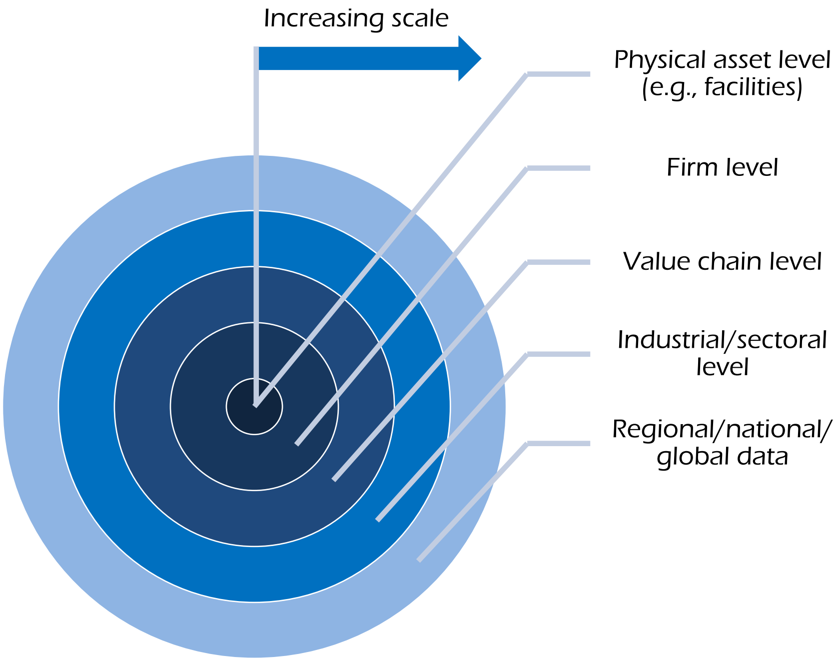
4. Typology of Environmental Data for Financial Analysis

We categorize environmental data used by the financial sector into five groups, based on a continuum from "micro" to "macro" level data. The categories include: physical asset-level data (or facility level data), firm-level data, value chain-level data, industrial/sectoral level data and regional/national/global level data. Such a categorization is subjective and only for illustrative purposes in this note, and we recognize that there are many other ways to classify environmental data (e.g., by usage, by user, by provider, etc.), and can also consider bundling asset/firm/value chain-level data into one group. See Table 2 below for an illustration of our typology.

Table 2: Typology of Environmental Data for Financial Analysis

Data type	Descriptions	Examples	Usages	Sources
Physical asset-level data (facility-level data)	Physical assets refer to facilities that generate GHG emissions and/or air, water and land pollutions.	Examples of facilities that generate GHG emissions include power plants, oil and gas operators (fields), and refineries. Major facilities that generate PM2.5 include power plants and steel/cement/chemical factories.	Aggregated facility level emission data can be used to assess environmental risks (and resulting credit risks) by borrowers. Such data can also be used for green ratings/rankings of the green performance of firms.	Environmental agencies (e.g., US EPA); NGOs (e.g., IPE) that aggregate and process facility-level data collected by regulators. Raw data are typically reported by owners or operators of facilities to regulators based on legal or administrative requirements.
Firm-level data	Environmental performance data of particular companies; Compliance data of particular companies.	CO_2 emission by particular companies; SO_2 and NO_X emissions by particular companies; Penalties paid on violating environmental rules by particular companies.	Labelling "green" or "brown" companies/projects; Developing green indices, rankings and ratings; estimating company-level risk exposures.	Corporate disclosures; Environmental agencies; 3rd party data providers, NGOs.
Value-chain level data	Value chain includes suppliers, clients or other business partners that have close relationships with the companies in question	Suppliers' and purchasers' environmental performance data and compliance data	Assessing business partners' environmental risks or strengths. Used in green supply chain management and green trade financing	Corporate disclosures; Environmental agencies; 3rd party data providers.
Industrial/ sectoral data	Industrial average or standard data on environmental performance, such as emission per unit of production.	National averages or policy guidelines for emissions for industries (e.g., CO_2 and SO_2 emission per KWh of electricity, per ton of steel and cement).	Assessing the efficiency/ dependency/exposure of an investment relative to its peer group (e.g., information that a power utility is highly water-efficient with low normalized emissions compared to its peers could alter its risk profile)	Government agencies; Science institutes.
Regional/ national/ global data	Macro data that helps identify environmental risk scenarios and estimating their impacts.	Projections of natural disasters; Demand/supply projections of natural resources (energy, water, forestry, soil, etc.).	Setting scenarios for analysing physical and transition risks (e.g., 2°C analysis); Projecting demand and cost of industries that have environmental impacts; Projecting policy responses, quantifying environmental externalities.	IOs; Governments; Science institutions.

Figure 1: Environmental Data Typology



Much firm-level data and facility-level data (e.g., by power plants or refineries) originate from corporate disclosures. They are reported by companies and facility owners/operators, and sometimes are integrated or consolidated by third party data providers such as CDP, Bloomberg, Thomson Reuters, MSCI and IPE. The TFCD is working on voluntary principles for improving climate-related corporate disclosures. However, not all facility- and firm-level data are based on voluntary disclosures by corporates. Some regulatory agencies also collect and report facility- and firm-level PAED. Such data are sometime based on mandatory reporting by firms/facility owners, and in other cases collected directly by meters (e.g., for measuring air and water pollutions) installed by the regulatory agencies. For example, China's Ministry of Environmental Protection and its local bureaus publish lists of polluting companies and release emission data of major facilities, and the US Environmental Protection Agency also provides domestic GHG emissions at the facility/firm level.

Industrial/sectoral data and regional/national/global data, especially those on future environmental scenarios and demand/supply projections of natural resources, largely come from public data sources such as governments, international organizations, NGOs, and science institutes, although some sectoral data are aggregated from facility/firm level information. Such sector/macro-level data often provide important contexts and assumptions for assessing financial asset or firm-level risks and opportunities.

On the whole, existing commercial data offerings are weighted towards the provision of benchmarked corporate-level performance data (e.g., intensity of emissions relative to industrial norms, or "greenness" of companies). However, most of the existing corporate-level data has been used for backward-looking analysis of how "green" or "brown" companies have been. In order to conduct risk analysis and identify green opportunities, which is forward-looking in nature, financial firms will need to have reasonable assumptions of future scenarios of how temperatures, probabilities of natural disasters, supply of and demand for natural resources (such as fossil fuel and renewable energy, water, forestry, soil, etc.) will change, how policies will likely respond to the changing environment, and by how much green/brown investment may improve/harm the environment. Such information is largely beyond the scope of corporate disclosure, but requires more concerted efforts from the public sector.

Most of the public information as described above is essentially a "public good" in nature. Once created, it can be used by an unlimited number of users without incurring additional costs. Gathering and disseminating such information requires employing individuals with specific skill sets (e.g., for projecting probabilities of climate-related events and building/interpreting hydrological models) and investments into building data platforms. It is very difficult for individual financial services institutions to use such investments sustainably and profitably within their typical business model. Public institutions (including some NGOs), however, do have business models suited for and comparative advantages in producing data of this type. From this perspective, the public sector has a responsibility to ensure its provision and accessibility. This is analogous to existing models in the finance sector where some data (e.g., monthly labour and inflation statistics) are produced by the government but used by financial institutions free of charge.

It should also be noted that the utility of the PAED extends beyond the analysis of corporate-level risks and opportunities. It can also be used by national governments and local authorities that need to formulate green investment policies, and by investors that are interested in specific assets such as infrastructure and private equity funds.

5. Examples of Publicly Available Environmental Data

In this section, we present nine examples of PAED sources at different levels, which are useful for financial analysis. Broadly speaking, these can be grouped into three types of data: (i) physical trends (e.g., global warming, pollutions/emissions, water stress, green technology development, etc.); (ii) forecasts (based on e.g., physical trends as well as expected policy responses); and (iii) environmental externalities. The nature of the data varies, with some being static and their relevance declining over time, whereas some other data provide more forward-looking information.

A few financial firms such as banks, insurance companies and asset managers already use some of these data, but most of the global financial industry has yet to develop the awareness of the relevance (or even the existence) of such data for green finance. The purpose of this section is to give illustrative examples on where such data are located, and how they can help environmental risk analysis and financial decision-making.

5.1. Scenarios of Climate Change and Projections on Natural Disaster Probabilities

Climate change scenarios are commonly used assumptions for environmental risk analysis by financial firms. These scenarios affect the probabilities of natural disasters such as flooding, droughts and hurricanes. They may also result in unexpected liabilities for insurance companies and cause impairments to assets held by banks and institutional investors. This section provides a brief overview of three sources of projections on these scenarios and their implications for natural disaster probabilities.

IPCC: Mean surface temperature change and sea level rise

The Synthesis Report of the Intergovernmental Panel on Climate Change (IPCC) fifth Assessment Report (AR5) finds that human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent changes in the climate have had widespread impacts on human and natural systems. Continued emissions of GHG will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems.

Table 3: Projected Change in Global Mean Surface Temperature and Global Mean Sea-level Rise for the mid and late 21st Century, Relative to the 1986-2005 Period

		2046-2065		2081-2100	
	Scenario	Mean	*Likely* range	Mean	*Likely* range
Global Mean Surface Temperature Change (˚C)	RCP2.6	1	0.4 to 1.6	1	0.3 to 1.7
	RCP4.5	1.4	0.9 to 2.0	1.8	1.1 to 2.6
	RCP6.0	1.3	0.8 to 1.8	2.2	1.4 to 3.1
	RCP8.5	2	1.4 to 2.6	3.7	2.6 to 4.8
	Scenario	Mean	*Likely* range	Mean	*Likely* range
Global Mean Sea-level Rise (m)	RCP2.6	0.24	0.17 to 0.32	0.4	0.26 to 0.55
	RCP4.5	0.26	0.19 to 0.33	0.47	0.32 to 0.63
	RCP6.0	0.25	0.18 to 0.32	0.48	0.33 to 0.63
	RCP8.5	0.3	0.22 to 0.38	0.63	0.45 to 0.82

Source: IPCC

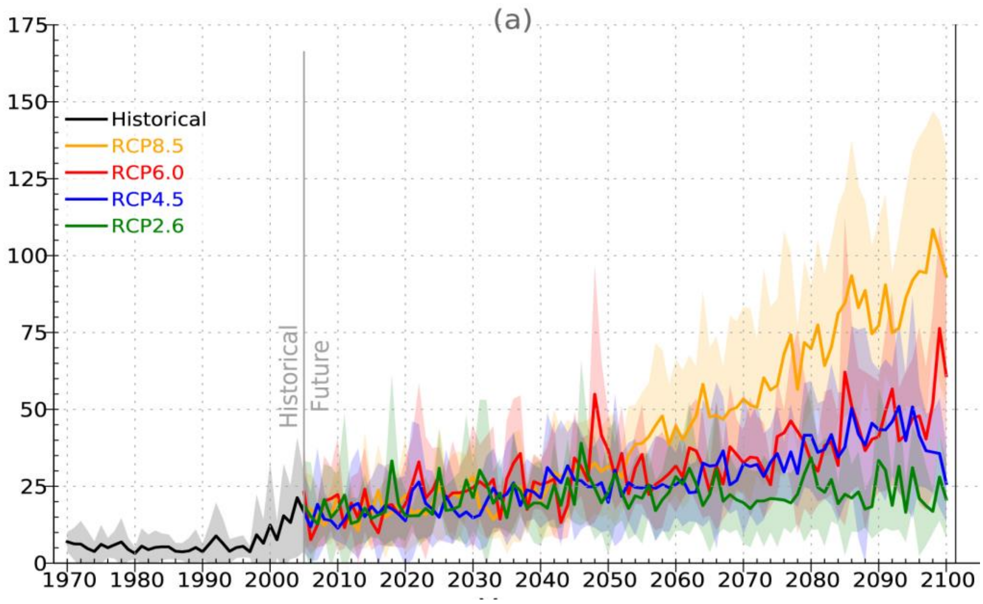
Representative Concentration Pathways (RCPs) are four greenhouse gas concentration (not emissions) trajectories adopted by the IPCC for its AR5 in 2014. The RCPs are consistent with a wide range of possible changes in future human GHG emissions. RCP 2.6 assumes that global annual GHG emissions peak between 2010-2020, with emissions declining substantially thereafter. Emissions in RCP 4.5 peak around 2040 and then decline. In RCP 6, emissions peak around 2080 and then decline. In RCP 8.5, emissions continue to rise throughout the 21st century.

The AR5 projected that the global mean surface temperature change for the period 2016-2035 relative to 1986-2005 is similar for the four RCPs, and will likely be in the range 0.3°C to 0.7°C (medium confidence) warmer than the period 1850-1900. Global surface temperature change for the end of the 21st century (2081-2100), relative to 1850-1900, is projected to likely exceed 1.5°C for RCP4.5, RCP6.0 and RCP8.5 (high confidence). Warming is likely to exceed 2°C for RCP6.0 and RCP8.5 (high confidence), more likely than not to exceed 2°C for RCP4.5 (medium confidence), but unlikely to exceed 2°C for RCP2.6 (medium confidence).

Global flood risk under climate change

Yukiko Hirabayashi[4] and colleagues presented global flood risk for the end of this century based on 11 climate models. They looked at changes in flooding and evaluate its consistency and spread. The team predicted an increase in flood frequency in Southeast Asia, Peninsular India, Eastern Africa and the northern half of the Andes. In addition to the global-scale analysis, the models were analysed at the outlets of selected river basins. The models suggested that during the 21st century, the frequency of floods would increase in almost all the selected rivers in South Asia, Southeast Asia, Oceania, Africa and Northeast Eurasia. They also projected that the 20th century 100-year flood event will occur about every 10-50 years in many of these rivers in the 21st century.

Figure 2: Number of People (in Million) Exposed to Flooding

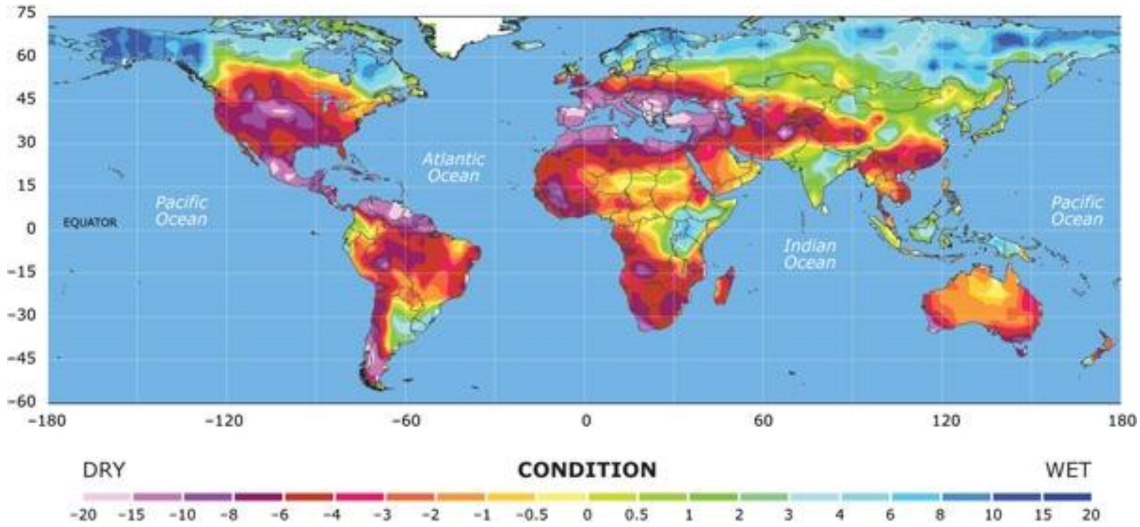


Source: Hirabayashi Y. et al. (2013)

Drought under global warming: projected drought conditions in the 2060s

This paper by Aiguo Dai[5] reviewed literature on droughts in the last millennium, followed by an update on global aridity changes from 1950 to 2008, as well as model projections of increased aridity in the 21st century over most of Africa, southern Europe and the Middle East, most of the Americas, Australia, and Southeast Asia. The report stated that regions like the United States have avoided prolonged droughts during the last 50 years due to natural climate variations, but might see persistent droughts in the next 20-50 years.

Figure 3: Projected Drought Conditions in the 2060s



Source: Dai, A. (2011)

5.2. Forecasts of Energy Demand Shift

Energy demand shift, as a result of policy response to pollution and climate change, will significantly affect the commercial viability of traditional high-carbon energy projects (such as oil and coal). At the same time, it could significantly raise the demand for renewable sources of energy such as wind, solar, hydropower and biofuels, and improve the commercial viability for sustainable buildings and green infrastructure. Projections of future energy demands by product are therefore critical for assessing financial risks and opportunities by investors and other financial market participants. However, projections vary by organization and underlying assumptions/scenarios. This section summarizes the energy demand forecasts from the International Energy Outlook (IEO) 2016 by the Energy Information Administration (EIA) and the World Energy Outlook (WEO) 2016 by the International Energy Agency (IEA).

The EIA forecasted that in 2012-20 world total energy consumption would increase by an average of 1.7% per year but decrease to 1.3% per year in 2020-40. Under the current policies and incentives for use of non-fossil energy sources in many countries, renewable energy is expected to be the world's fastest growing source of energy, at an average rate of 2.6% per year between 2012 and 2040, while nuclear energy increases by 2.3% per year, and natural gas increases by 1.9% per year. Coal is the world's slowest growing form of energy, at an average rate of 0.6% per year (compared with an average increase of 1.4% per year in total world energy demand). In terms of renewable energy, the IEO2016 Reference case (without considering the effect on the US of the Clean Power Plant rules) projects an average growth of 4.0% per year in 2012-20.

Table 4: Comparison of IEO2016 and IEA World Energy Consumption Growth Rates by Energy Source for 2012-2020 and 2020-2040 (Average Annual Percent Growth Rate)

	2012–2020		2020–2040	
Energy source	IEO2016	IEA[a]	IEO2016 Reference Case	IEA Current Policies Scenario
Petroleum and other liquids	1.3	1.1	0.9	0.9
Natural gas	1.3	1.6	2.1	1.8
Coal	1.2	1.1	0.3	1.4
Nuclear	3.0	3.6	2.0	1.1
Renewables	4.0	2.4	2.1	1.5
Total	**1.7**	**1.5**	**1.3**	**1.3**

Source: EIA (2016)

The WEO 2016 projects that consumption of all modern fuels continues to grow in 2014-40 in the New Policies Scenario (assuming the implementation of the announced climate pledges submitted for COP21),[6] whereas growth in coal is cut to 0.2% per year on average in 2014-40. But renewable energy is the major growth story: in the power sector, 60% of all capacity additions to 2040 are renewable, at an average annual growth rate of 6.9% even not including hydropower and bioenergy. By 2040, wind and solar combined have more installed capacity than any other source of electricity.

There are also more aggressive projections for growth of renewable energy. The 450 Scenario (assuming a pathway to limit long-term increase in temperatures to 2°C) pushes the deployment of renewable energy significantly beyond the levels implied by today's measures and policy intentions. In this scenario, global coal demand drops sharply, at a rate of 2.6% per year. By 2040, world coal consumption is only half that in the New Policies Scenario and coal's share in primary energy supply has dropped to 13%. At the same time, renewable energy is the leading source of supply by the early 2020s and nearly 60% of all supply in 2040, with a projected average annual growth rate at 9.1% without considering hydropower and bioenergy (Table 5).

Table 5: World Energy Demand by Source in Different Scenarios (Mtoe)

New Policies Scenario

	2000	2014	2020	2025	2030	2035	2040	CAAGR* 2014-2040
Coal	2 316	3 926	3 906	3 955	4 039	4 101	4 140	0.2%
Oil	3 669	4 266	4 474	4 577	4 630	4 708	4 775	0.4%
Gas	2 071	2 893	3 141	3 390	3 686	4 011	4 313	1.5%
Nuclear	676	662	796	888	1 003	1 096	1 181	2.3%
Hydro	225	335	377	420	463	502	536	1.8%
Bioenergy**	1 026	1 421	1 543	1 633	1 721	1 804	1 883	1.1%
Other renewables	60	181	339	478	643	835	1 037	6.9%
Total	**10 042**	**13 684**	**14 576**	**15 340**	**16 185**	**17 057**	**17 866**	**1.0%**

*Compound average annual growth rate. ** Includes the traditional use of solid biomass and modern use of bioenergy.

	Energy demand (Mtoe)						Shares (%)		CAAGR (%)	
	2020	2030	2040	2020	2030	2040	2040		2014-40	
	Current Policies Scenario			450 Scenario			CPS	450	CPS	450
TPED	14 819	17 183	19 636	14 204	14 468	14 878	100	100	1.4	0.3
Coal	4 051	4 710	5 327	3 622	2 650	2 000	27	13	1.2	-2.6
Oil	4 548	4 960	5 402	4 345	3 883	3 326	28	22	0.9	-1.0
Gas	3 194	3 898	4 718	3 136	3 349	3 301	24	22	1.9	0.5
Nuclear	793	936	1 032	815	1 234	1 590	5	11	1.7	3.4
Hydro	375	450	515	378	486	593	3	4	1.7	2.2
Bioenergy	1 540	1 695	1 834	1 550	1 928	2 310	9	16	1.0	1.9
Other renewables	319	535	809	359	939	1 759	4	12	5.9	9.1

Source: IEA (2016)

The differing levels of policy ambition determine the share of renewable energy in the primary energy mix in the scenarios: from 8% in 2014 to 13% by 2040 in the Current Policies Scenario; 16% in the New Policies Scenario; and 27% in the 450 Scenario. In terms of final energy consumption, the share of renewable energy in the mix goes from 9% in 2014 to 13% in 2040 in the Current Policies Scenario; 16% in the New Policies Scenario and 26% in the 450 Scenario. In all scenarios, the long-term trend of increasing electrification continues, with the relative role of renewable electricity strengthening in line with energy-related climate policies and declining technology costs.

Table 6: World Renewable Energy Consumption by Scenario

		New Policies		Current Policies		450 Scenario	
	2014	2025	2040	2025	2040	2025	2040
Primary demand (Mtoe)	1 161	1 786	2 837	1 705	2 528	2 017	4 049
Share of global TPED	*8%*	*12%*	*16%*	*11%*	*13%*	*14%*	*27%*
Traditional use of solid biomass (Mtoe)	776	744	619	748	629	742	612
Share of total bioenergy	*55%*	*46%*	*33%*	*46%*	*34%*	*43%*	*27%*
Electricity generation (TWh)	5 383	8 960	14 271	8 384	12 305	9 890	19 883
Bioenergy	495	785	1 353	754	1 151	843	1 899
Hydropower	3 894	4 887	6 230	4 817	5 984	4 994	6 891
Wind	717	2 118	3 881	1 859	3 132	2 575	6 127
Geothermal	77	150	361	141	299	181	548
Solar PV	190	953	2 137	761	1 539	1 153	3 209
Concentrating solar power	9	61	254	49	170	137	1 118
Marine	1	6	54	3	30	7	92
Share of total generation	*23%*	*30%*	*37%*	*27%*	*29%*	*36%*	*58%*

Source: IEA (2016)

5.3. Projections of Water Stress

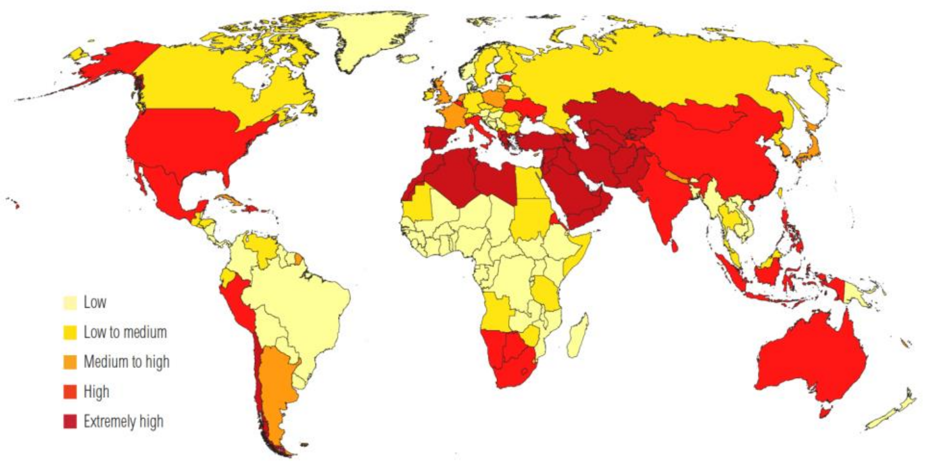
According to data provided by the Global Water Institute[7] (GWI), the earth's water supply totals 1.4 billion km^3, of which 97.5% is oceanic. The remaining 2.5% is fresh water, of which 70% is frozen, 30% is groundwater, and only 0.3% is accessible as surface water. Of available renewable freshwater, 54% is already appropriated by humanity through irrigated agriculture (70%), industry (22%), and domestic use (8%). With water demand expected to increase by 55% by 2025 according to the OECD, the water stress situation may pose serious challenges to companies that depend on water supply. Rising scarcity of water implies higher costs of operations, and may result in asset impairment. Financial risk analysis and valuations of water-dependent sectors and companies therefore require quality forecasts of future water demand and supply.

Several agencies, including the World Resources Institute (WRI), the International Water Management Institute (IWMI), UN Environment, the World Bank, the OECD and the European Environment Agency have developed global forecasts for the next few decades on water demand, supply and water stress maps. Such information is critical for "water stress analysis" for countries, regions, corporates and physical assets.

WRI: Water Stress Projections Data[8]

The Aqueduct Water Stress Projections produced by WRI include indicators of change in water supply, water demand, water stress and seasonal variability, projected for the coming decades under scenarios of climate and economic growth.

Figure 4: Country-level Water Stress in 2040



Note: Ratio of withdrawals to supply: (i) Low (<10%) (ii) Low to medium (10-20%) (iii) Medium to high (20-40%) (iv) High (40-80%) (v) Extremely high (>80%)

Source: WRI (2015)

With the goal of producing information for decadal-scale planning, adaptation and investment, this analysis models potential changes in future demand and supply of water over the next three decades. Globally, WRI estimates indicators of water demand (withdrawal and consumptive use), water supply, water stress (the ratio of water withdrawal to supply), and intra-annual (seasonal) variability for the periods centred on 2020, 2030, and 2040 for each of two climate scenarios, RCP4.5 and RCP8.5, and two shared socioeconomic pathways, SSP2 and SSP3. WRI derived estimates from general circulation models (GCMs) from the Coupled Model Inter-comparison Project Phase 5 (CMIP5) and mixed-effects regression models based on projected socioeconomic variables from the International Institute for Applied Systems Analysis (IIASA)'s Shared Socioeconomic Pathways (SSP) database.

IWMI: Projected Water Scarcity in 2025[9]

The Global Water Scarcity Study produced by the IWMI is an important new planning tool for the worldwide water and development community. The first phase of its research, completed in 1998, forecasts future water supply and demand in 118 countries worldwide. The second phase (completed in 2000) makes use of the IWMI Policy Dialogue Model (PODIUM), a software-based planning tool that helps countries shape their water and food security policies for the coming years. Several countries are currently using PODIUM data for policy planning, by including more detailed water and food production data. Forecasts using PODIUM data include:

1. By 2025, some 2 billion people in 45 countries will live in absolute water scarcity. Most have to import a large portion of cereal consumption.

2. To meet water needs, the world must develop 22% more primary water supply, and 17% more must be provided to irrigation to meet food needs.

3. The world must continue investing in water development projects to meet food demands, and in research to improve crop water productivity.

UN Environment: Overview of the World's Fresh and Marine Waters to 2025[10]

This report's goal is to produce a clear overview of the current state of the world's fresh, coastal and marine waters, and forecasts trends in water scarcity. It illustrates the causes and effects of trends that threaten our water resources, with examples of areas of major concern and future scenarios for the use and management of fresh, coastal and marine waters. The following are several key conclusions from this study:

1. By 2050, the number of countries facing water stress or scarcity could rise to 54, with a combined population of 4 billion people.

2. 36 countries are projected to face chronic freshwater shortages, including parts of China and some other large countries. Nearly 230 million Africans will face water scarcity, and 460 million live in water-stressed countries.

3. Saudi Arabia's freshwater comes from fossil groundwater, and is depleted at an average rate of 5.2 km^3 per year.

OECD: Water demand and quality outlook by 2050[11]

The OECD documents some of the consequences of having too much, too little, or too polluted water. Subsequent work has focused on managing water scarcity, water quality, and water-related disasters. It has identified governance and finance as essential enabling conditions. The following are several key conclusions from this study:

1. Water demand will increase 55% by 2050 from manufacturing, electricity and domestic use, mainly in BRICS, with little scope for expanding irrigation.

2. The number of people living in river basins under severe water stress is projected to more than double by 2050, reaching 3.9 billion, half of the world population.

3. Water quality is projected to deteriorate due to wastewater, and the level of pollution discharge in oceans will also increase significantly.

4. 240 million people will still lack access to improved sources of water in 2050 due to population growth and urbanization.

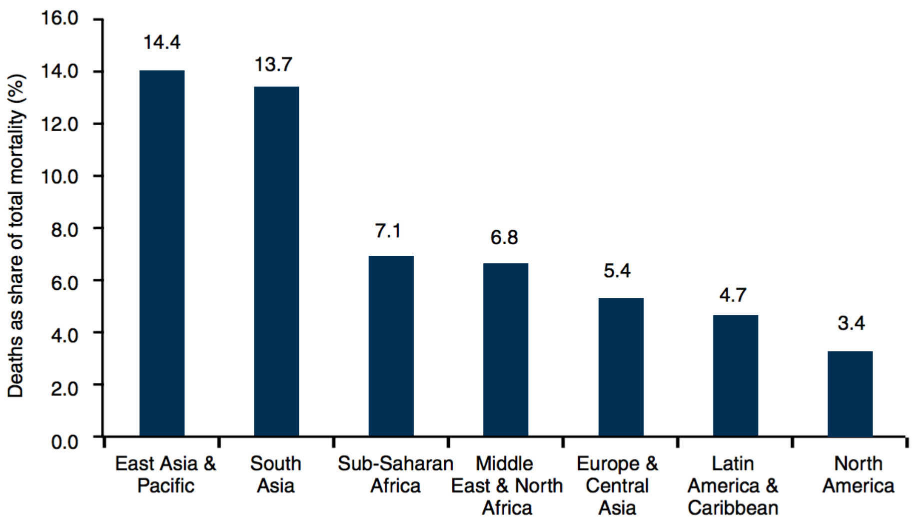
5.4. Costs of Air Pollution (and Benefits of Air Pollution Reduction)

In assessing green investment demand, a very important analysis is to quantify the environmental benefits of green projects. Green projects can deliver environmental benefits, such as reductions in air, water and land pollution. They are often labelled as "green projects" and need to be promoted in a green financial system. On the other hand, projects that damage the environment – by creating air, water and land pollution – are often labelled as "brown projects" and should be discouraged, based on the estimated "costs" of pollution.

The quantification of environmental benefits of green projects (due to reduction in pollution) and costs of pollution can be roughly divided into two steps. The first is to quantify the reduction (or increase) in pollution in physical terms (e.g., number of tons of SO_2 and NO_X, or number of tons of wastewater or solid waste) by a green (brown) project. The second step, which is more difficult, is to estimate the social and economic costs of pollution. Many studies in this area are still in their early stages as methodologies for estimation are still evolving. This section introduces several studies on the costs of air pollution. Sections 5.5-5.6 will present studies on the costs of water and land pollution.

Health risks. According to the World Bank and the Institute for Health Metrics and Evaluation,[12] in 2013, 5.5 million premature deaths worldwide, or 1 in every 10 total deaths, were attributable to air pollution, which was the fourth leading fatal health risk. The health risk posed by air pollution is the greatest in developing countries. In 2013, about 93% of deaths and non-fatal illnesses attributed to air pollution worldwide occurred in these countries, where 90% of the population was exposed to dangerous levels of air pollution. Children under 5 years of age in lower-income countries are 60 times as likely to die from exposure to air pollution as children in high-income countries.

Figure 5: Percentage of Total Deaths due to Air Pollution by Region, 2013



Sources: World Bank and IHME (2013)

Social and welfare losses. From 1990 to 2013, welfare losses caused by air pollution doubled and labour income losses increased by 40%. In 2013, exposure to ambient and household air pollution cost the world's economy some US$5.1 trillion in welfare losses.[13] The OECD estimated in 2014 that outdoor air pollution cost OECD countries plus China and India an estimated US$3.5 trillion dollars a year in terms of the value of lives lost and ill health.[14] It also forecast that outdoor air pollution could cost the world US$2.6 trillion a year, or 1% of global GDP by 2060.[15]

The welfare losses (Table 7) represent the cost stemming from premature mortality caused by exposure to ambient fine particulate matter (PM2.5), household air pollution from cooking with solid fuels, and ambient ozone. The magnitude of losses was greatest in East Asia and the Pacific, where premature mortality costs reached the equivalent of 7.5% of GDP in 2013, closely followed by South Asia, where costs were on the order of 7.4% of GDP equivalent.

Table 7: Total Welfare Losses from Air Pollution, by Region (1990-2013), in 2011 US$ billion, PPP-adjusted

Region	1990	1995	2000	2005	2010	2013
East Asia and Pacific	439	630	805	1,199	1,822	2,306
Europe and Central Asia	1,308	1,226	1,188	1,301	1,259	1,245
Latin America and Caribbean	105	101	104	127	167	194
Middle East and North Africa	74	82	98	118	144	154
North America	516	544	578	576	514	495
South Asia	135	174	214	303	497	604
Sub-Saharan Africa	61	63	76	90	107	114
Total	2,638	2,821	3,063	3,714	4,510	5,112

Sources: World Bank and IHME (2013)

Cost to agriculture. Pollutants may adhere to plant surfaces and reduce the amount of sunlight reaching crops, stunting their growth. In China, surface ozone (a major component of smog) has reduced yields of summer wheat by an estimated 6-12% and soybeans by an estimated 21-25%. The World Bank and the Chinese environmental authority estimate the cost of acid rain and SO_2 pollution on agricultural output in China at RMB30 billion a year (2003 prices).[16]

5.5. Costs of Water Pollution (and Benefits of Water Pollution Reduction)

Many studies show that water pollution could be very costly. In addition to direct and indirect economic costs, water pollution could also bring disease and premature deaths. The World Bank found in China that the impact is particularly high in rural areas, and attributed excess deaths due to diarrhoea among children under 5 in rural areas to a lack of safe water supply.[17] On the other hand, water pollution reduction could bring benefits, including cost efficiencies, health improvement, community relations, and even energy saving due to reduced energy consumption for wastewater treatment.

OECD: Health Costs of Inaction with Respect to Water Pollution

The work on the "costs of inaction to water pollution" was initiated by the OECD at the request of environment Ministers in April 2004.[18] The OECD found that the health costs of policy inaction linked to water pollution can be considerable. Improving environmental conditions upstream to prevent environment-related health problems from developing can be far more effective than trying to treat health problems when they arise further downstream.

1. **Policy interventions can reduce mortality and morbidity-related health costs associated with water-related diseases.** However, the economic value of the health benefits of water supply and sanitation policy interventions are sometimes underestimated when setting priorities, planning and budgeting in the sector.

2. **Economic valuation studies demonstrate that the health benefits associated with drinking water supply and sanitation interventions can be significant.** Economic studies related to water supply and sanitation interventions reviewed in OECD countries have found benefit-cost ratios which vary from 1 to 2.3, suggesting **significant cost savings in terms of healthcare expenditures.**

Table 8: Cost-benefit Analyses of Improving Drinking Water Supply and Quality of Recreational Waters through Sewage Treatment in OECD Countries

Environmental interventions	Studies	Costs	Health Benefits	BCR
Improving drinking water quality in the USA	USEPA, 2006	USD 93 to 133 million per year	Traditional COI: USD 130 million - 2.0 billion	1.0
			Enhanced COI: USD 177 million - 2.8 billion per year	1.3
Improving the drinking Water quality and storm Water management in the USA	Gaffield et al., 2003	Drinking water: USD 33.0 billion / Runoff control: USD 9.3 billion (20-year period)	USD 2.1-13.8 billion per year (COI based on secondary literature)	≈ 1
Improving the security of water supply in Seoul (Korea)	Kwak and Russell, 1994	Unfavourable assumption: USD 92.9 million / Favourable assumption: USD 25.3 million per year	Unfavourable assumption: USD 91.4 million/ Favourable assumption: USD 121 million per year	1.0
Improving the quality of recreational waters in the UK	Georgiou and al., 2005	GBP 2.4 to GBP 5.2 billion for a 25-years period	25% reduction of illness: GBP 11.9 billion/ 100% reduction: GBP 22.8 billion for a 25-years period	2.3
Improving the quality of recreational waters in the Netherlands	Brouwer and Bronda, 2005	EUR 50 million for a 20-years period	EUR 2.4 billion for a 20-year period	48.0

Note: BCR=benefit-cost ratio, COI=cost of illness.

Source: OECD (2008)

Natural Resources Defense Council: Water Efficiency Saves Energy

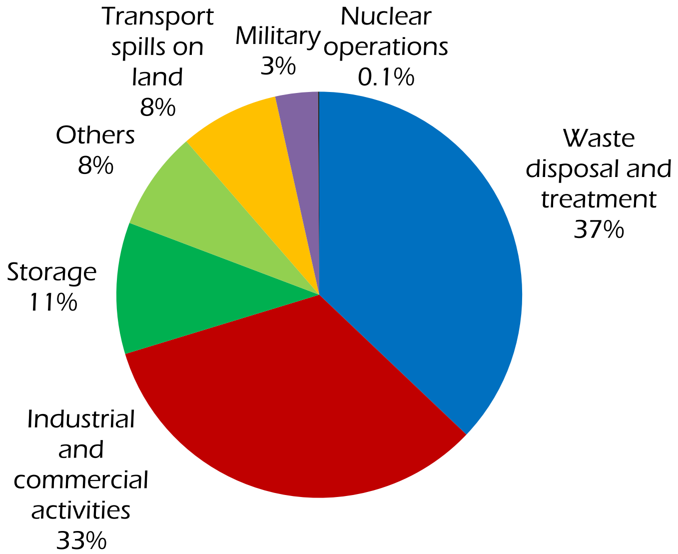
The US Natural Resources Defense Council (NRDC), a not-for-profit organization, published a report on the connection between water and energy, which found another benefit of water pollution reduction.[19] One of its main findings is that the collection, distribution, and treatment of drinking water and wastewater nationwide consume tremendous energy and release approximately 53 million tons of CO_2 per year, the equivalent to the annual GHG emissions of 10 million cars.

5.6. Costs of Land Contamination (and Benefits of Land Remediation)

Examples of land contamination can be found in every country, developing or developed. Contaminated land that previously has been used as a factory, mine, steel mill, refinery or landfill, often cannot be used for human habitation or agriculture for a long period of time, leading to a significant decrease in value and a high cost for remediation.

Data on land contamination in Europe and the world: More than 2.5 million sites in 38 European countries are potentially contaminated, and 342,000 sites have been identified as contaminated. The diffuse contamination by salinization affected 4 million hectares in the Mediterranean region in 1998 but more recent and systematic data on trends across Europe are missing. About 35% of the land area of Poland is acidified. Further, model results indicated that about 15% of the EU-25 land surface experiences soil nitrogen surplus more than 40 kg of nitrogen per hectare.[20]

Figure 6: Sectors Contributing to Soil Contamination in Europe



Source: Institute for Advanced Sustainability Studies (2014)

As in Europe, industrial activities, agricultural chemicals or improper disposal of waste contaminate soils in other parts of the world. Agricultural activities contribute to soil degradation and diffuse soil pollution by introducing pollutants or toxic substances like cadmium by application of mineral phosphate fertilizers. Another example concerns the US, where about 435,000 underground storage tanks, many of them containing hydrocarbons, have leaked and contaminated soils. Nearly 1.5 million underground storage tanks have been closed since 1984 but the number of sites that need remediation is difficult to estimate. Worldwide, the magnitude of the problem is much larger but the extent less well known. Specifically, a comprehensive inventory on the global extent of soil contamination is lacking.

Costs of land contamination: The destruction of the Fukushima Daiichi nuclear power plant in March 2011, caused by an earthquake and subsequent tsunami, resulted in massive radioactive contamination of land. The precise value of the abandoned cities, towns, agricultural lands, businesses, homes and property located within the roughly 800 km^2 of the exclusion zones has not been established. Estimates of the total economic loss range from US$250-500 billion.[21] Figures from China's Ministry of Environmental Protection revealed that in 2013, 19.4% of arable land was polluted,[22] and total clean-up costs could eventually exceed RMB7-10 trillion.[23]

Table 9: Estimated Remediation Costs of a Contaminated Site

Remedial Option	Cost per acre-foot (US$ thousand)
Consolidation and covering contaminated soil on site (i.e., under roads and structures)	1-2
Cap contaminated soil with clean soil	7-12
Blending with clean soil from on-site	1-2
Blending with clean soil from off-site	8-15
Excavation and removal of contaminated soil	32-80
Proven and innovative soil treatment technologies	50-100

Source: New Jersey Department of Environmental Protection (1999)

Remediation of contaminated land is very costly. According to the New Jersey Department of Environmental Protection, the costs of remediating a pesticide-contaminated site vary depending on the concentration and distribution of the contamination, the size and layout of the site, and the remedial actions implemented. The following table presents its cost estimates associated with each remedial option presented above for 1 acre of contamination that is assumed to be 1-foot-deep (1-acre foot). These costs are based on the remediation of undeveloped farmland. Remediation costs could rise dramatically for existing development due to difficulties associated with the movement of soil around existing structures, trees, pools and decks. In addition, the remediation of properties with existing development would not have the benefits of economy of scale associated with undeveloped land.

Benefits of land remediation: The transformation of East London into the 2012 Olympic Park is an example of successful remediation. The regeneration of the land included 2,200 separate land interests and a diverse range of contaminant sources. In total, 2.2 million m^2 of soil was excavated, of which 764,000 m^2 was treated by soil washing, chemical stabilization, bio-remediation or sorting. 80% of the excavated materials were reused on site as engineering fill. Since the Olympic Games, the site has become the largest new urban park in Europe, with 100 hectares of open land and 45 hectares of new habitat. Some 2,800 new residents have moved into the Athletes' Village.

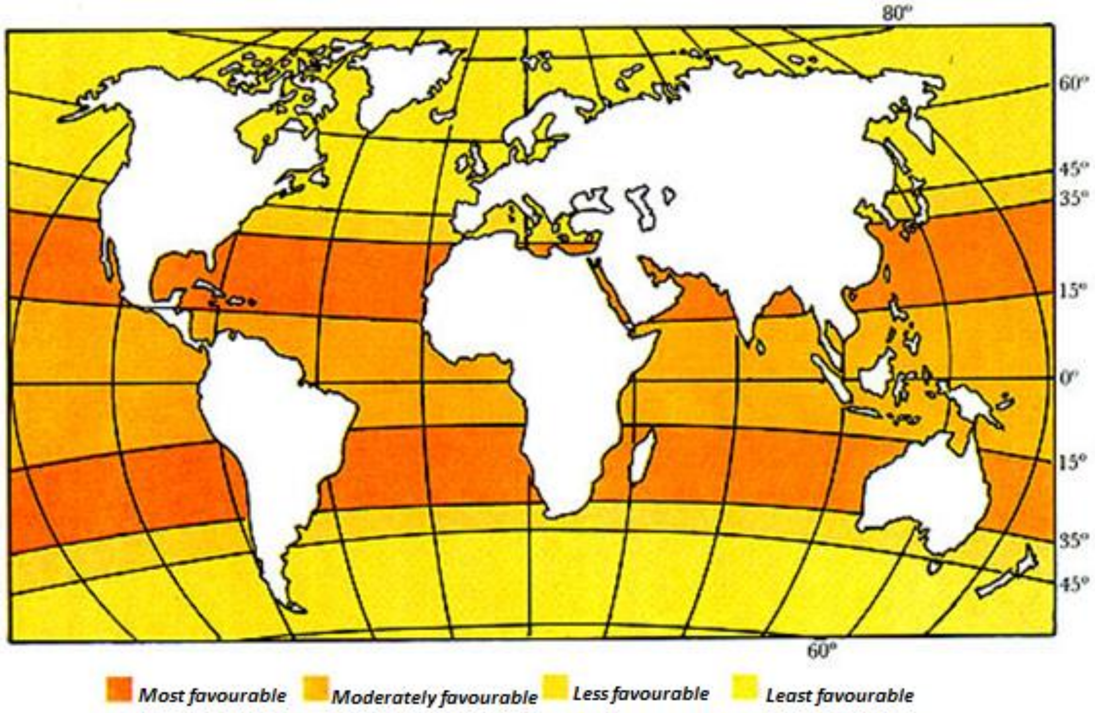
5.7. Data on Solar and Wind Resources

Renewable energy has become a fast-growing green industry over the last decade. The WEC, the IPCC and several UN bodies expect a significant share of renewables in the future as a percentage of the total energy mix with major contribution from bioenergy, hydropower, wind and solar energy. With the help of satellite technologies, many financial institutions are using data on renewable resources, such as maps of solar radiation and wind speed, to make projections on the financial outlook (productions, revenues and costs) of renewable projects.

Globally, solar resources are abundant. The sun could be the world's largest source of electricity by 2050, ahead of fossil fuels, wind, hydropower and nuclear, according to a pair of reports issued by the IEA in September 2014. The IEA technology roadmaps show how solar photovoltaic (PV) systems could generate up to 16% of the world's electricity by 2050 while solar thermal electricity from concentrating solar power (CSP) plants could provide an additional 11%. The IEA reports state that, combined, these solar technologies could prevent the emission of more than 6 billion tons of CO_2 per year by 2050 – that is more than all current energy-related CO_2 emissions from the US or almost all of the direct emissions from the transport sector worldwide today.

Solar radiation is unevenly distributed, and it varies in intensity from one geographic location to another depending upon the latitude, season and time of day. For convenience and simplicity, the geographic distribution of total solar radiation is divided in terms of intensity into four broad belts around the earth,[24] in both the northern and southern hemispheres.

Figure 7: Worldwide Distribution of Solar Radiation into Belts Indicating Feasibility of Solar Applications



Source: Acra, A. et al. (1984)

1. **The most favourable belt.** This belt, lying between latitudes 15˚, and 35˚, has the greatest amount of solar radiation. More than 90% is direct radiation due to the limited cloud coverage and rainfall (less than 250 mm per year).

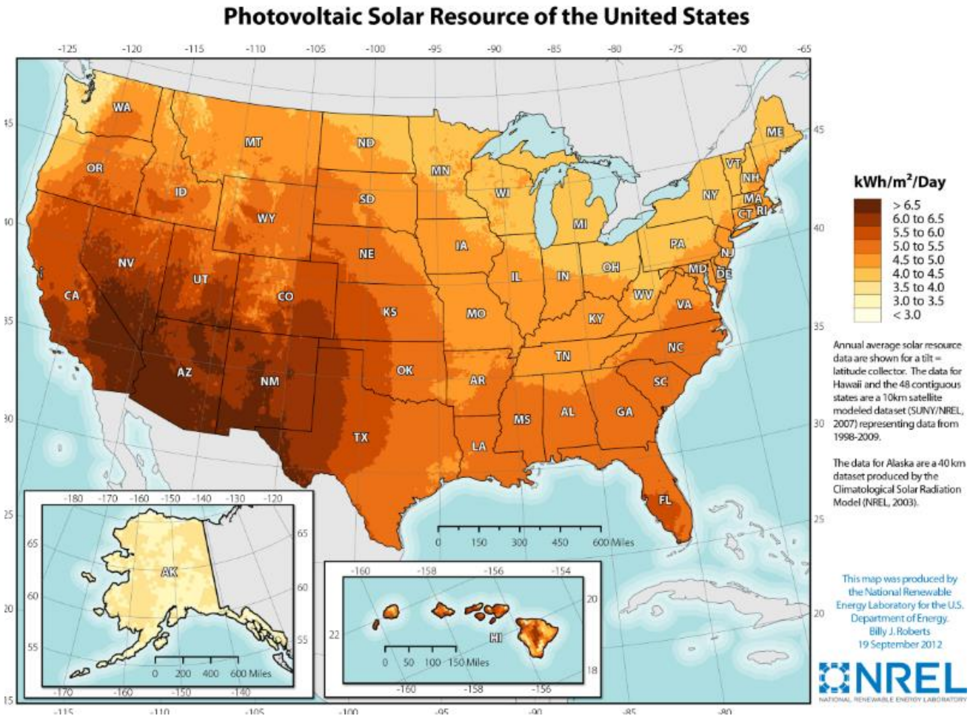
2. **Moderately favourable belt.** This belt lies between the equator and latitude 15˚, with a total of about 2,500 hours of sunshine per year. The solar intensity is relatively uniform throughout the year as the seasonal variations are slight.

3. **Less favourable belt.** This belt lies between latitude 35˚ and 45˚, with marked seasonal variations in both radiation intensity and daylight hours.

4. **Least favourable belt.** The regions in this belt lie beyond latitude 45˚, where about half of the total radiation is diffuse radiation.

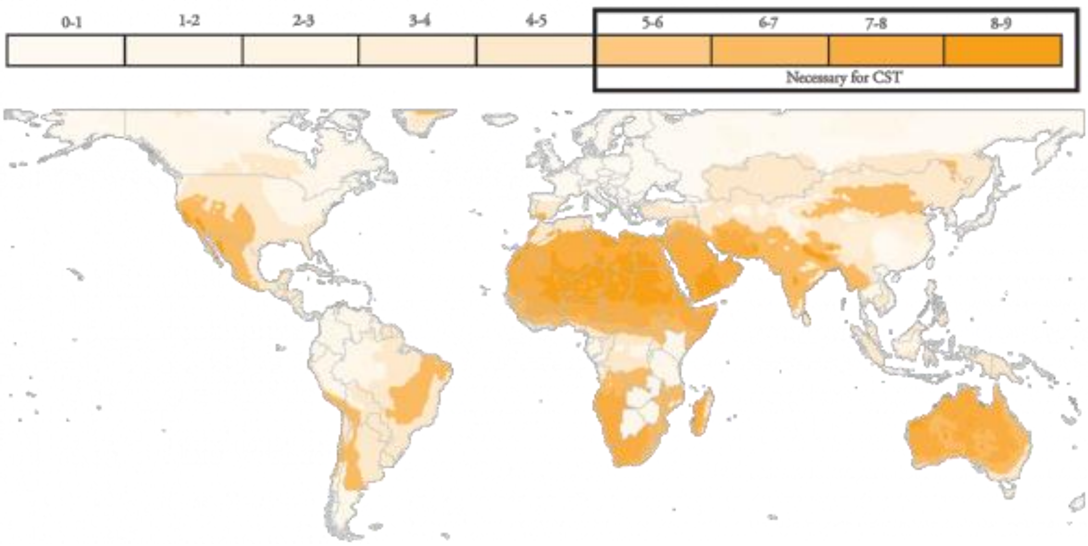
The US National Renewable Energy Laboratory (NREL) provides solar resource maps of monthly average daily total solar resource information on grid cells, showing solar PV resource potential as follows:

Figure 8: US Solar PV Resource Potential 1998-2009



Source: NREL

Figure 9: Global Direct Normal Solar Radiation of May 2009



Source: WRI

The use of wind power is increasing rapidly over time. Cumulative global installed capacity stood at 467 GWe in 2016, and a significant further increase is expected. On a global scale, various studies have assessed the technical potential of wind energy onshore.[25] The global technical potential of wind electricity is estimated to be 96 PWh per year: about 6-7 times the world electricity consumption in 2001.[26]

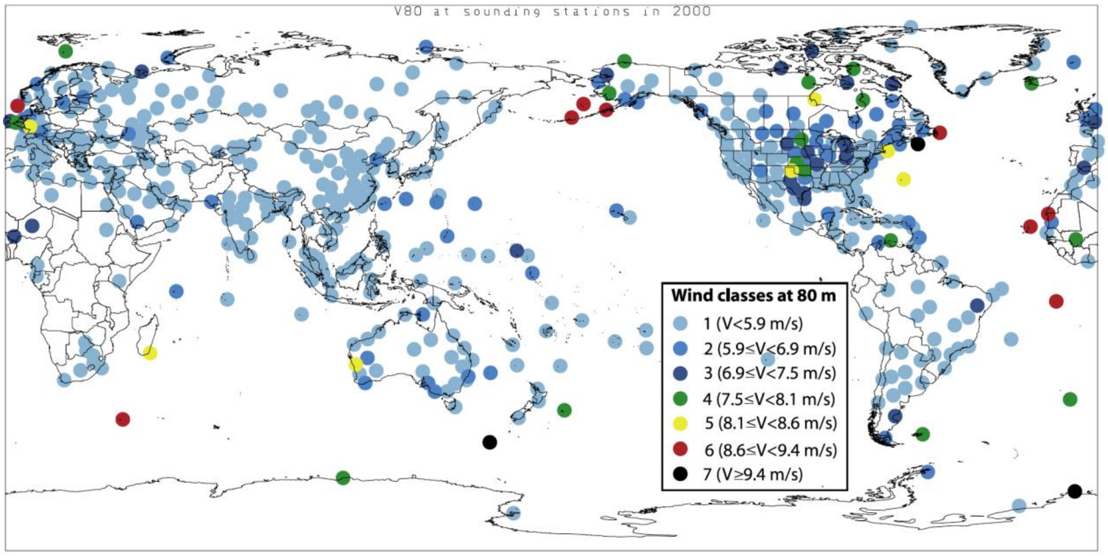
Table 10: Regional Distribution of the Area, Suitable Area, Regional Average Wind Speed, Technical Potential and Technical Potential at Different Cut-off Costs

	Area (Mha)	Suitable area (Mha)	Average wind speed (m s^{-1})	Average power density (MW km^{-2})	Technical potential (PWh $year^{-1}$)	Technical potential cut-off 0.07 US$ kWh^{-1} (PWh $year^{-1}$)	Technical potential cut-off 0.10 US$ kWh^{-1} (PWh $year^{-1}$)	Ratio technical potential and present electricity consumption[a]
Canada	950	199	4.1	1.08	19	8	16	32.7
USA	925	248	4.3	1.02	21	3	13	5.6
Central America	269	29	3.3	0.40	2	1	1	10.5
South America	1,761	82	3.0	0.26	8	4	6	13.0
North Africa	574	55	2.9	0.42	3	0.00	0.04	23.3
West Africa	1,127	4	1.8	0.01	0.2	0.00	0.04	5.7
East Africa	583	38	2.6	0.28	3	0.00	0.23	358.3
South Africa	676	3	2.2	0.03	0.2	0.00	0.00	1.0
Western Europe	372	47	4.3	0.58	4	1	2	1.6
Eastern Europe	116	6	3.1	0.22	0.4	0.01	0.1	1.0
Former USSR	2,183	206	3.4	0.47	16	2	7	12.6
Middle East	592	47	3.1	0.33	2	0.00	0.00	5.6
South Asia	509	15	2.3	0.12	1	0.00	0.00	1.9
East Asia	1,108	25	2.4	0.10	2	0.00	0.05	1.1
South East Asia	442	0	2.0	0.01	0.03	0.00	0.00	0.1
Oceania	838	199	3.6	0.91	14	1	6	68.5
Japan	37	1	3.3	0.08	0.1	0.00	0.01	0.1
Global	13,063	1123	3.0	0.37	96	21	53	7.0

[a] We use the IEA data of 1996 on the present electricity consumption at a regional level for this ratio as these were available at the same regional aggregation. These data are, however, lower than present consumption data.

Source: Hoogwijk, M. et al. (2004)

Figure 10: Map of Wind Speed Extrapolated to 80m and Averaged over All Days of 2000 at Sounding Locations with 20 or more Valid Readings.



Source: American Geophysical Union (2005)

5.8. Physical Asset (Facility) Level Data

Physical asset (facility) level data refers to environmental information on physical assets, such as GHG emissions by power plants, oil operators (fields), refineries and chemical plants, as well as SO_2, NO_X and wastewater emissions by facilities such as power plants, steel, cement and textile factories. Such data are often collected as a mandatory requirement by the environmental authorities, and reported by either the collector such as the US Environmental Protection Agency (EPA) or through a third party such as the Institute of Public and Environmental Affairs (IPE), an NGO in China. Supply chain management uses these data to identify "green suppliers", and some financial firms use them to quantify the "greenness", or carbon footprint, of companies, after the facility-level information is consolidated or mapped into companies and financial assets. In this section we summarize the cases of facility-level data offerings by the US EPA and China's IPE.

US EPA FLIGHT tool

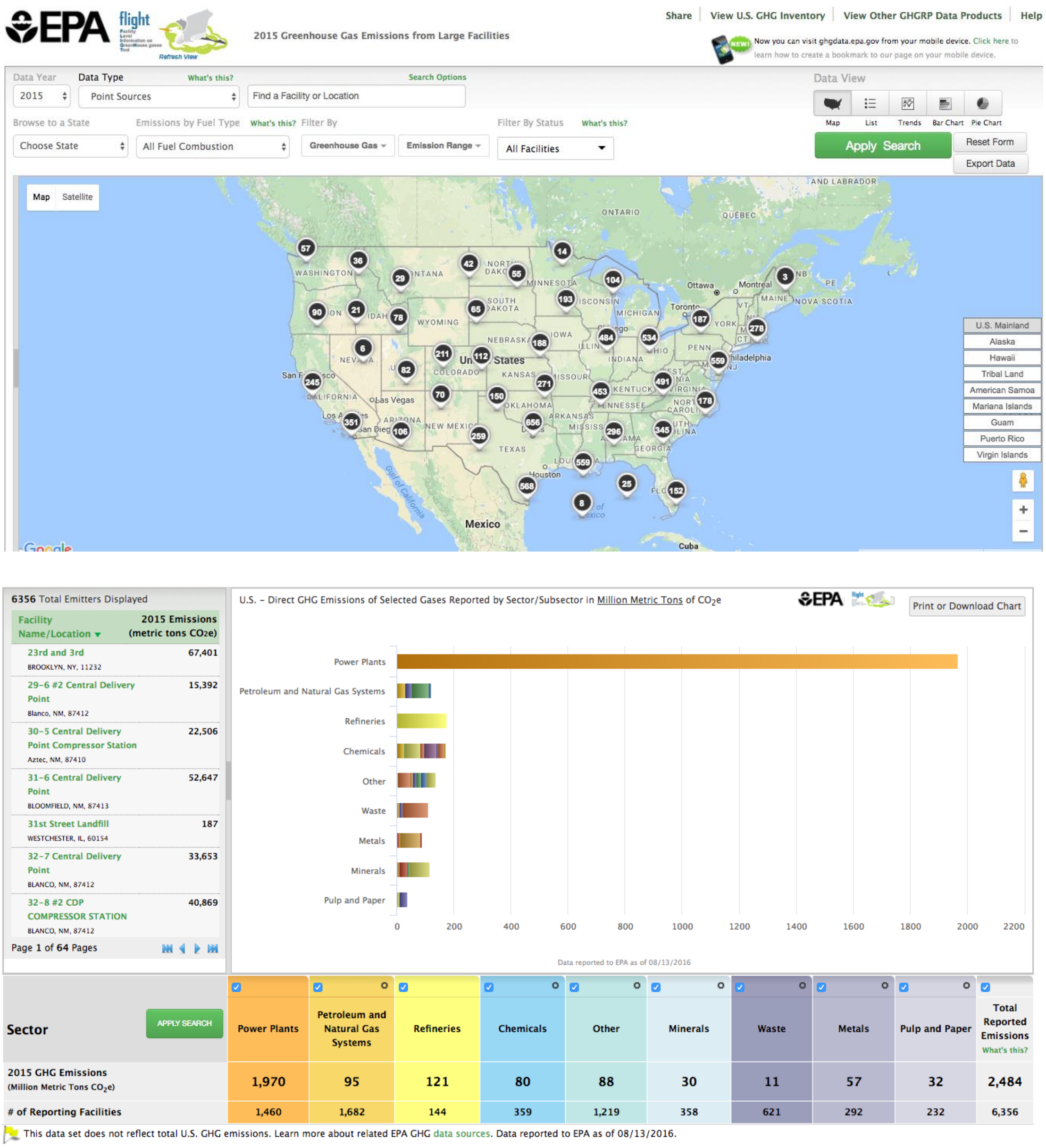
The US EPA runs the US Greenhouse Gas Report Program (GHGRP). It requires the reporting of GHG data and other relevant information from large GHG emission sources, fuel and industrial gas suppliers, and CO_2 injection sites in the US. The GHGRP covers a total of 41 categories[27] of reporters. Facilities determine whether they are required to report based on the types of industrial operations located at the facility, their emission levels or other factors. Facilities are generally required to submit annual reports if:

1. GHG emissions from covered sources exceed 25,000 metric tons CO_2e per year;
2. The supply of certain products would result in over 25,000 metric tons CO_2e of GHG emissions if those products were released, combusted, or oxidized;
3. The facility receives 25,000 metric tons or more of CO_2 for underground injection.

The Facility Level Information on Greenhouse Gases Tool (FLIGHT) is the interactive website portal of the GHGRP.[28] This provides facility level access to GHG reported to EPA by the three categories of reporters listed above. FLIGHT allows data to be visualized in several formats including maps, tables, charts and graphs for individual facilities or groups of facilities. The data set can be searched for individual facilities by name or location. Data can also be filtered by: state or county; fuel type; industry sectors and sub-sectors; annual facility emission thresholds; and GHG type. Emission trends over time can also be produced.

Data linked to each individual facility includes: city and state; latitude/longitude; North American Industry Classification System (NAICS) code;[29] facility ID; emissions trend over multiple years; emissions information for the selected year; total facility emissions in metric tons CO_2e; emissions by gas and emissions by source/process.

Figure 11: Examples of US EPA FLIGHT Web-based Tool



Source: NREL

The GHGRP is developed using bottom-up methods and covers roughly 85% to 90% of total US GHG emissions.[30] This includes direct emissions data reported by stationary sources but does not include emissions from the agriculture and land use sectors or direct emissions from sources that have annual emissions of less than 25,000 metric tons of CO_2e. It also does not include sinks of GHGs. The GHGRP differs from the US GHG inventory, which is EPA's official source of total US emissions. The inventory is developed using (primarily) top-down methods and covers all sectors of the economy.

IPE Pollution Maps

IPE is a non-profit environmental research organization registered and based in Beijing. Since its establishment in June 2006, IPE has dedicated itself to collecting, collating and analysing government and corporate environmental information to build a database for public usage.

IPE's two platforms, the Pollution Map website and the Blue Map app, integrate environmental data collected from various publicly available sources, mostly from environmental protection authorities at different levels.

The Pollution Map website includes environmental quality information, emissions data and pollution source supervision records from 31 provinces and 338 cities in China. As of December 2015, the number of supervision records exceeded 220,000. Through the Blue Map app, users can search and retrieve air quality information from 390 cities in China, as well as 3,879 water quality stations in 364 cities, and key pollution sources in real time monitoring data from 15,074 enterprises.

Besides data provision, IPE also processes data and develops research reports or rankings. Two important rankings are the Pollution Information Transparency Index (PITI) and Corporate Information Transparency Index (CITI). With the PITI, IPE conducts an annual evaluation of the status of key pollution sources monitoring information disclosure in cities across China. By doing so, IPE can encourage governments to disclose more environmental data. With CITI, IPE also conducts an annual evaluation on big brands' supply chain environmental performance, with a particular focus on transparency. By doing so, IPE can help incentivize large companies and their smaller suppliers to disclose environmental information and improve compliance performance.

IPE’s data can be used for green procurement, green finance and government environmental policymaking. For instance, brands can use the Pollution Map database to manage environmental performance of their suppliers in China. So far, IPE has successfully helped over 1,600 suppliers to improve their environmental performance. Meanwhile, financial institutions such as HSBC and IFC have used the IPE database for auditing the environment performance of firms in lending decisions.

Figure 12: IPE Pollution Map

Source: IPE

5.9. Green Technologies

Green technologies refer to those that are environmentally more friendly than traditional technologies. Examples of green technology subject areas include those used, among others, for producing green energies, constructing green buildings, enhancing the efficiency of resource use, waste treatment, and green supply chain management. Information on green energy technologies are collected by international organizations, governmental institutions, research institutes and universities, as well as third party data providers. These databases are used to track the developments in green technologies and their applications by investors, policymakers, entrepreneurs and researchers. In this section, we review two examples of green technology databases: WIPO Green, an interactive database hosted by the World Intellectual Property Organization (WIPO), and Climate TechWiki, a database developed in partnership with UNDP, UN Environment, REEEP and others.

WIPO GREEN

WIPO GREEN[31] is an interactive platform that consists of an online database and a network that brings together a wide range of players in the green technology innovation value chain. By building a bridge between green technology suppliers and seekers, WIPO GREEN aims at catalysing innovation and deployment of green technologies, and also helping developing countries to tackle climate change.

The WIPO GREEN's database offers a broad listing of green technology products, services and intellectual property assets, which are available for license, collaborations, joint venture and sale. These entries are either uploaded directly by the registered users or made in accordance with data sharing agreements between WIPO GREEN and its partners. This freely accessible database therefore becomes a useful resource for investors, entrepreneurs and licensing managers looking to achieve deals in the green technology field. It also advertises technological needs for individuals and companies.

While the database adds greater transparency to the green technology market, the WIPO GREEN network helps facilitate commercial relationships and transactions by providing matchmaking services and events among its diverse members, including small or medium-sized enterprises (SMEs), consultants, multinational companies, financing institutions, intergovernmental organizations, NGOs and academics.

ClimateTechWiki

ClimateTechWiki[32] is an online database with up-to-date and updatable information about technologies for climate change mitigation and adaptation. As a supporting tool for the Handbook for Conducting Technology Needs Assessment for Climate Change,[33] ClimateTechWiki is developed to:

- Increase people's familiarity with technologies that reduce GHG emissions or support adaptation to climate change；
- Prioritize technologies with the help of multi-criteria decision analysis; and
- Identify activities to accelerate the development and transfer of prioritized technologies within the country.

To provide comparable and assessable technology information, ClimateTechWiki describes technologies in a structured way with fixed headings. The descriptions mainly include how a technology works, its feasibility in different contexts, its market potential and cost, its socio-economic and environmental implications, and case studies if applicable.

6. Gaps in Availability and Accessibility of Public Data

Based on discussions with specialists in the financial sector, there are several reasons why PAED is not yet widely used by the financial sector in risk analysis and the assessment of green investment opportunities. Some of the reasons are related to the lack of awareness by many financial institutions that environmental exposure may pose risks to them, and the lack of formal "mandates" for channelling financial resources to projects that can deliver environmental benefits. These issues could be addressed via the promotion of voluntary principles for green finance, as discussed in the 2016 G20 Green Finance Synthesis Report.

A number of other obstacles are also constraining the effective usage of public environmental data, and include:

1. **The nascent state of environmental risk analysis and methodologies for green financial assessment.** Methods for environmental risk analysis have just been developed by a few banks, insurers, asset managers and academic institutions, and are not yet publicly available to most other financial firms. There is often an associated lack of employees with the relevant technical skills within many financial institutions. Methods for quantifying environmental benefits/costs of projects are also hugely complex, vary depending on sectors and regions, and are underdeveloped in many countries. The lack of such analytical tools and methodologies for many financial institutions results in limited demand for environmental data.

2. **Lack of commonly accepted future scenarios and clarity of future policy responses to environmental and climate challenges.** Some key assumptions for risk analysis are made by individual financial firms on an ad hoc basis, leading to potential communication problems. Other financial market participants that are interested in but have not yet started with such an analysis have wondered which assumptions should be used. Financial institutions that have already conducted environmental analysis of risks and opportunities also complain that many other macro parameters – such as future demand for renewable energy and potential technology breakthroughs that may feature in scenario analysis (e.g., carbon capture and storage, and cost reduction in solar power), as well as likely policy actions taken against polluting sectors and incentives for green investments – are very uncertain, resulting in a lack of confidence in the assumptions for analysis.

3. **PAED are often presented in unfamiliar ways to financial market users.** For example, some metrological data and forecasts are written in units that are not commonly used or understood by financial analysts and their economic implications are not well explained in technical reports. Some public data are not standardized or not comparable. For example, IWMI projections focus on change in water supply, while the WRI reports forecasts on water withdrawals, and their benchmark for comparisons and timelines for their projections are different. It is therefore difficult for financial users to compare the scenarios.

4. **Some public data sources are not widely known or easily accessible.** The analysis for risks and opportunities by financial institutions requires many different types of environmental data, some examples of which were discussed in the previous chapter. However, these databases are typically located in many different sources, with some only existing as text in certain publications. It is therefore time-consuming for most financial firms that are relatively new to environmental analysis to search and obtain such data. Some public data, such as those at the facility level, are not yet mapped to financial assets and firms, and thus are difficult to use

for financial analysis. Some data are consolidated and presented by third party data providers, but they charge user fees for access.

5. **Uncertainty over the business models for PAED provision.** Based on the debate among specialists from NGOs, science institutes, government agencies and private data providers, there is not yet a clear model of who should be the main providers of public data relevant for financial analysis. There are cases for government agencies and IOs to consolidate and provide PAED, but there are also potentially alternative business models for private data providers or NGOs to offer PAED at lower prices (e.g., public data without additional analytical services).

7. Options for Improving Publicly Available Environmental Data

In light of the above discussions on barriers to the effective usage of PAED by financial analysis, we list here a few options for improving the availability, accessibility and relevance of PAED:

1. **Improving the availability of methodologies for environmental risk analysis and for quantifying environmental costs and benefits.** Only with robust methodologies will financial institutions begin to seek data for implementation. The GFSG work on encouraging the development and application of methodologies for Environmental Risk Analysis is an important step towards improving their availability to the financial industry. Some research institutes and NGOs have also developed methodologies for quantifying the costs of pollutions and benefits of green projects that can reduce pollution.[34] It may be necessary for selected IOs or specialized research institutions to host such information on a public website for easy and zero-cost access by financial institutions globally.

2. **Improving the comparability and user friendliness of PEAD.** Such efforts may include developing internationally accepted definitions, indicators, scenarios and forecasts, as well as better mapping PAED to financial assets. In addition, some forms of international collaboration that result in the publication of an "Annual Report on Environmental Data for Financial Analysis" could also be useful in enhancing international consistency or comparability of data.

3. **Consolidating or providing a guide to PAED, initially on the global level.** Efforts could be made by selected IOs or specialized agencies to develop a one-stop-shop for PAED, initially on the global level, which could substantially reduce the "search cost" for financial institutions. Information contained in such a one-stop-shop could include, among others, climate change scenarios and their impacts on natural disaster probabilities; global forecasts for energy demand and supply (including fossil fuels and renewable energy); projections of water supply, demand and shortages; costs of air, water and land pollutions as well as benefits of reductions in pollutions; and green technology databases. Alternatively, the GFSG can support appropriate IOs, such as UN Environment and the OECD, to produce a catalogue of PAED, which involves minimum efforts but can go a long way in improving the awareness of the existence and the locations of such data.

4. **Promote country-level consolidation and sharing of PAED for financial analysis.** Such initiatives, in the form of one-stop shops, data catalogues or data-sharing agreements, could be taken by environmental agencies, financial regulators, third party data providers or NGOs. They can focus on developing easier access to domestic PAED and improving their relevance to financial institutions in the local contexts.

Appendix: Corporate Disclosures

Corporate disclosure of ESG information first began in the early 1990s and has dramatically accelerated over the last decade to become common practice among large, listed companies around the world. Given the voluntary nature of most reporting, it is difficult to construct a comprehensive picture, but research on the 100 largest companies across 45 countries found approximately 75% of companies issuing reports containing ESG information and 92% of the 250 largest companies in the world issue reports.[35] Sufficient public information exists to allow commercial data providers to carry information on as many as 10,000 companies.

To date, most ESG disclosure has been voluntary in nature and guided by frameworks pioneered through international initiatives over the last 20 years. The most widely used framework for corporate responsibility reporting has become the Global Reporting Initiative, which is used by over two thirds of companies issuing reports.[36] However, other frameworks have been launched that also seek to define ESG disclosure in the context of annual reports and regulatory filings. The Sustainability Accounting Standards Board (SASB) and the Investor Responsibility Research Center (IRRC) are the most prominent internationally, and are complemented by a handful of national frameworks. Index providers, such as the Dow Jones Sustainability Index score companies on a wide range of sustainability indicators. Some industry sectors have joined together to develop sector reporting guidelines to build consensus among the industry.

However, as reporting has become an increasingly common practice and investors seek to integrate ESG into investment decision-making, regulators have begun to evaluate whether and how to make reporting mandatory.[37] At the national level, countries are taking different approaches. The US has opted for issuing guidance and other non-binding requirements.[38] In July 2015, France strengthened mandatory climate disclosure requirements for listed companies and introduced the first mandatory requirements for institutional investors as part of Article 173 of the *Law for the Energy Transition and Green Growth*.[39] The most ambitious single disclosure rule has been issued by the European Union that will affect all companies of more than 500 employees. However, stock exchanges and securities regulators in other locations such as Hong Kong, Singapore, South Africa and Denmark have issued mandatory disclosure requirements and, in some cases, these include details down to the level of key performance indicators (KPIs). In the general, trends point towards increasing the use of regulation to drive disclosure.

ESG disclosure has been undergoing substantial evolutions in its form. Since the 1990s, ESG information has primarily been disclosed in the form of stand-alone reports that go by varying names and were not necessarily directly tied to a financial filing or reporting cycles. However, companies (with the encouragement of investors) have begun to integrate more environmental information into their financial reports and some companies have gone to the step of issuing a single 'integrated' reporting that combines both their ESG information and their financial report. KPMG cites 50% of annual reports as containing environmental information, but only 10% consider themselves 'integrated.'

Despite the dramatic growth in the volume of available disclosure, the quality of information disclosed remains variable, which has been a complaint within the industry. Most companies do not engage external assurance providers and environmental data may not be subject to the same level of internal controls as financial information. Given the voluntary nature of reporting and difference across legal jurisdictions around rules for compilation of certain types of data (e.g., emissions, health and safety, etc.), reports are not necessarily consistent across sectors and regions on what they cover or how they compile information. However, the volume and quality of data has been sufficient to enable the development of a commercial ESG data sector and the development of a growing portfolio of ESG investment products.

The type of information included in reports generally relates to those aspects that are under the control or direct influence of companies and relate to the company's own performance. The typical disclosure will include a combination of narrative information to introduce the company's strategic perspective and management approach and quantitative information in the form of indicators related to emissions and resource consumption. Disclosure may also extend to aspects related to corporate products (e.g., fleet emissions) or its supply chain. Typical environmental disclosures will cover areas such GHG and other air emissions, water, energy, waste streams, and land use as they relate to a company's operations as well as its products and supply chains where relevant. These types of disclosures are generally either benchmarked against those of other companies or analysed in parallel with other environmental data to analyse the relative risks and opportunities facing a company.

One of the consistently challenging factors around environmental data disclosure has been understanding its materiality and applications in the course of investment. The materiality of environmental data often does not lie in its direct translation into costs and revenues. For example, energy or water efficiency brings measurable cost savings to a company, but usually in modest amounts. However, a reduction in consumption that enables a company to retain a secure supply of water or erects a competitive barrier has an enormous strategic value for the execution of a business plan. Therefore, environmental performance information often requires contextualization in order to derive its greatest value.

Among environmental issues, climate risk disclosure has captured the greatest interest and attention in recent years. The FSB TFCD has been launched to provide recommendations on how to improve climate risk disclosure and has issued its report in June 2017, including both a framework for disclosure and a number of supporting recommendations.

In response to growing investor demand, environmental data service provision has fully penetrated the mainstream market. Starting from a set of boutique providers in the 1990s, the industry has undergone waves of consolidation and most of the companies that dominate the commercial data service industry (e.g., Bloomberg, MSCI, Thomson Reuters, etc.) now offer various forms of ESG data services. For the most part, these service providers tend to rely on corporate disclosures or other sources for raw data (including databases maintained by the public sector and international organizations), which they process and convert into data feeds, ratings and other analytics for investors and lenders.

Another barrier for the integration by financial services companies of ESG data into decision-making is the number of companies reporting these data. CDP, which holds the largest database of non-party self-reported environmental data globally, receives approximately 6,000 company disclosures through its investor-backed climate change information request annually. In order to enhance company coverage to the level required for portfolio analyses, CDP (as well as other data service providers) has developed models for estimating GHG emissions from non-reporting companies. It has made its methods publicly available in an effort to harmonize differing approaches (that only serve to confuse data consumers) and promote the use of its data for asset owners and managers to meet their obligations under the Montreal Pledge, Portfolio Decarbonization Coalition, or Article 173 of France's Energy Transition Law, among other applications (e.g., development of low carbon indices).

The scope of commercial environmental data offerings covers many aspects of the data chain, including:

1. Data feeds and platforms: Over the last decade, major data platforms widely used within the financial industry have incorporated ESG information into their offerings. Bloomberg publishes data on usage of ESG information, which has shown an increase of over 680% over the last seven years. Data feeds and platforms typically allow users to track and analyse ESG and traditional financial information in conjunction with each other.

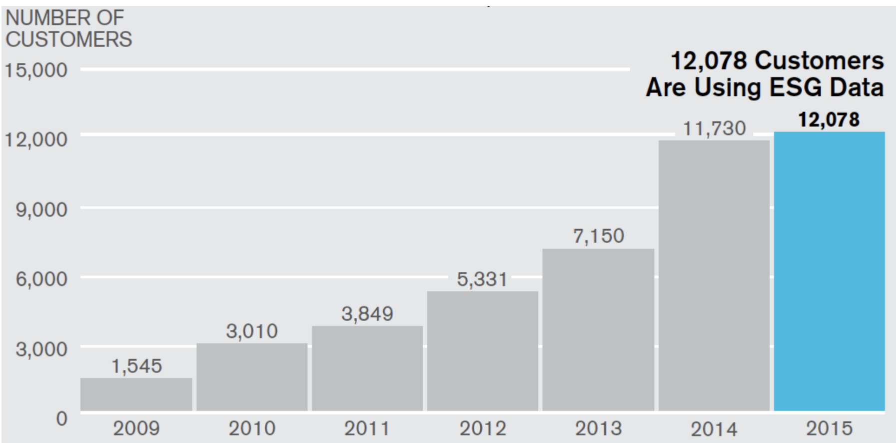
2. Company ratings and analysis: As a complement to investment indices, a number of mainstream and boutique service providers offer company ratings and profiles that target assessment of ESG performance. Company ratings are often delivered through sophisticated interfaces that allow users to conduct queries, searches and other types of inquiries regarding the contents. The specific rating methodologies are always proprietary formulas that reflect the service provider's professional assessment.

3. Brokerage research: The brokerage industry has been undertaking research that targets specific environmental themes and their impact on sectors as well as use of environmental data in generic sector reports for over a decade. These research reports are consistent with other research by investment banks with the exception that an environmental factor forms an integral part of their investment thesis.

4. Investment indices: Various types of ESG indices are now common offerings from the major ratings providers around the world. These indices include publicly available investment tools such as thematic indices (e.g., low-carbon), indices comprising best-in-class companies across sectors and regions, and bespoke indices that serve as portfolio benchmarks. The preparation of these indices involves the process of large volumes of raw data, but this data is not necessarily shared with the users of indices.

5. Specialized analytics tools: Beyond pure data feeds and applications of environmental data to traditional service offerings, a number of specialized analytics tools and providers emerge. These include offerings such as tools to track media services to identify reputational risks stemming from environmental factors, various tools for linking environmental data with financial risks and cost assessment, etc.

Figure 13: Changes in Use of ESG Data Since 2009



Source: Bloomberg (2015)

These various data offerings experience vary degrees of demand and application across the various pillars of the financial system (lending, capital markets, and insurance) and regions, but have generally been experiencing an upward trend.

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[1] Currently green assets held by institutional investors as % of their total holding are very small: for example, a recent survey of leading investors has identified US$138 billion in low-carbon investments, relative to more than over US$100 trillion in assets managed by institutional investors (Asset Owners Disclosure Project (2016) AODP 2016 Global Climate 500 Index).

[2] See Blackrock (https://www.blackrock.com/investing/insights/blackrock-investment-institute/climate-change) or Bank of England (http://www.bankofengland.co.uk/pages/climatechange.aspx)

[3] WRI's Aqueduct platform is an example of an open source platform comprising of multiple datasets, which also feeds into platforms such as Bloomberg or MSCI. More online at: http://www.wri.org/our-work/project/aqueduct

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[6] The main scenario in the WEO 2016, the New Policies Scenario, incorporates existing energy policies as well as an assessment of the results likely to stem from the implementation of announced intentions, notably those in the climate pledges submitted for COP21. The Current Policies Scenario includes only those policies firmly enacted as of mid-2016; this default setting for the energy system is a benchmark against which the impact of "new" policies can be measured. The 450 Scenario demonstrates a pathway to limit long-term global warming to 2 °C above preindustrial levels.

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[27] https://www.epa.gov/ghgreporting/resources-subpart-ghg-reporting

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[29] The North American Industry Classification System (NAICS) classifies business establishments for the purpose of collecting, analysing, and publishing statistical data related to the U.S. economy. The NAICS industry codes define establishments based on the activities in which they are primarily engaged.

[30] EPA has a multi-step data verification process. First, the EPA data entry tool (e-GGRT) used by facilities conducts data checks and provides feedback to reporters during the data entry phase. This occurs even before the data is submitted to EPA. Second, once the data has been submitted, EPA conducts a variety of automated data checks that include ensuring that reports are internally consistent, checking the data against expected ranges for similar facilities and industries, and statistical analysis. Based on the results of the automated checks EPA conducts a staff review of the reported data. EPA then follows up with facilities to resolve any mistakes that may have occurred.

[31] WIPO GREEN has been developed with a range of partners such as AUTM, EACIN, Eco-Patent Commons, KOTEC, OpenIX, TechnologieAllianz and UNOSSC. https://www3.wipo.int/wipogreen/en/

[32] http://www.climatetechwiki.org/

[33] The handbook is prepared by UNDP and the UNFCCC Secretariat.

[34] A number of NGOs and consultancies, such as CDP and Trucost, have developed methodologies for estimating GHG emissions from companies that do not report these data, including using regression analysis and bottom-up modelling approaches.

[35] https://www.kpmg.com/CN/en/IssuesAndInsights/ArticlesPublications/Documents/kpmg-survey-of-corporate-responsibility-reporting-2015-O-201511.pdf. See page 30.

[36] https://www.kpmg.com/CN/en/IssuesAndInsights/ArticlesPublications/Documents/kpmg-survey-of-corporate-responsibility-reporting-2015-O-201511.pdf. See page 42. The GRI is a non-profit organization based in the Netherlands that was initiated in 1997.

[37] The Principles for Responsible Investment have 62 trillion in AUM through its signatories. The PRI is posited on the assertion that ESG information can be material and should be given due consideration in the course of investment decision-making.

[38] One example is the SEC Guidance Regarding Disclosure Related to Climate Change. Online at: https://www.sec.gov/rules/interp/2010/33-9106.pdf

[39] The Energy Transition Law is broad legislation aimed at reducing French greenhouse gas (GHG) emissions, capping fossil fuel and nuclear production, and increasing renewable energy usage. In addition to these broad goals, the law contained an article— Article 173—aimed at increasing disclosure of climate change-related risks by listed companies and financial institutions (including institutional investors) as well as the alignment of institutional investors' portfolios with French and international climate policy.