Longer Term Investments

Clean air and carbon reduction

CIO WM Research | **13 April 2017**
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- Population growth and urbanization are driving the need for clean air innovations as GDP growth raises the use of fossil fuel-driven energy and hence, air pollution.
- Despite increased policy uncertainty and fragmented regulations, we think some companies are addressing the need for cleaner, more efficient energy sources. We see the global energy transition as an opportunity where companies and investors can benefit from rapidly advancing technologies and evolving markets.
- Based on estimated cumulative investment needs of around USD 36 trillion by 2030, we think the clean air and carbon reduction theme will enjoy good sales growth and mid-to-high single-digit earnings growth rates in the next two decades. Solution providers offering technologies and new innovations to reduce emissions will benefit the most from stricter emission regulations.

Our view

With some governments shifting key priorities and climate change initiatives facing less support, there is some policy uncertainty. However, we expect the core dynamics that drive the global energy transition towards low carbon technologies to be largely unaffected. We see four low carbon technologies that will continue to grow and reshape global industries:

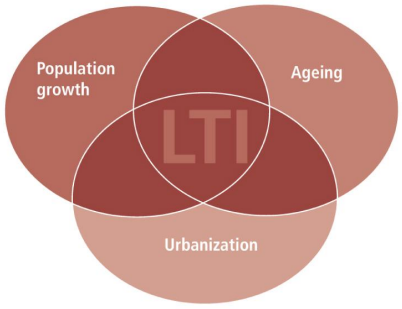
1. **Wind power**: 2016 was the industry's second best year (after 2015) in terms of global new installations;
2. **Solar photo-voltaic (PV)**: 2016 was a record year for global solar installations, with growth rates of about 50% versus the previous record year (2015);
3. **Electric cars**: Despite starting from a low base, electric vehicles and hybrids are likely to gain consumer acceptance and grow strongly along with big cost reductions and performance improvements; and
4. **LEDs**: Aggressive policy supports in major markets (the EU, the US and China) have been helping LEDs to rapidly take market share.

Rising populations and urbanization are the global trends fueling the need for clean-air technologies. In the past century, higher concentrations of greenhouse gases have increased the global temperature by 1°C.

Source: ClÈment Philippe, prismaonline

Introduction to the Longer Term Investments (LTI) series

- **The Longer Term Investments (LTI)** series contains thematic investment ideas based on long term structural developments.
- Secular trends such as population growth, ageing, and increased urbanization create a variety of longer term investment opportunities.
- Investors willing to invest over multiple business cycles can benefit from potential mispricings created by the typically shorter term focus of stock markets.



World population is expected to reach 8.5bn people by 2030 (from 7.2bn in 2014) and, together with continuous migration to urban areas, this will lead to increased economic activity.

With carbon dioxide (CO2) emissions growing in line with GDP, greater economic activity and higher energy consumption will lead to an urgent need to find sustainable ways of reducing emissions. Our theme should benefit from stricter, more environmentally-oriented standards and a focus to address climate change, reduce greenhouse gas emissions and improve air quality. This should result in good sales growth and mid-to-high single-digit earnings growth rates in the next two decades.

Introduction

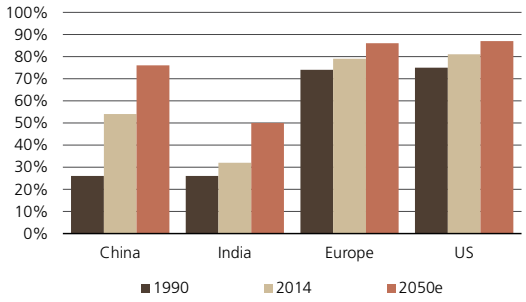
Clean air is a basic human need, yet preserving it has become more and more problematic. Air quality is degrading due to the ever-increasing concentration of greenhouse gases and particulates such as carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O) or ozone (O3) in the atmosphere. This situation is exacerbated by the growing trend of urbanization (see Fig. 1) and the greater energy consumption that results from it especially in developing countries. When the harmful carcinogens associated with particulates are absorbed into the lungs and bloodstream, DNA mutations and premature death may occur.

Carbon dioxide constitutes 78% of all greenhouse gases in the atmosphere, followed by methane and nitrous oxide (see Fig. 2). Long-term exposure to them and to the fine particulates emitted by vehicles increases the risk of cardiopulmonary disease, stroke, lung cancer and asthma. Emission-control technologies can lower the rates of these diseases. Particulates remain in the atmosphere for a long time, so sustainable long-term solutions are needed to improve air quality and address climate change. China, the US, the EU and India are the top four emitters, and account for 59% of global carbon emissions. (see Fig. 3). Emissions having been increasing substantially in recent decades, especially in non-OECD nations (see Fig. 4), and the International Energy Agency (IEA) expects them to continue rising sharply until 2035.

The problem: According to scientists, if the amount of carbon dioxide emitted by the world stays below the "carbon budget," there is a chance of limiting the rise in the global temperature to 2°C above pre-industrial levels (see Box 1). The carbon budget is estimated to be 3 trillion tons of carbon. However, in the last 150 years, the world has already used up to two thirds of this amount, leaving less than 1 trillion tons of CO2 emissions to limit the temperature increase and avoid the worst impacts of climate change. At current emission rates, the remaining carbon quota will be used up in about 20 years.

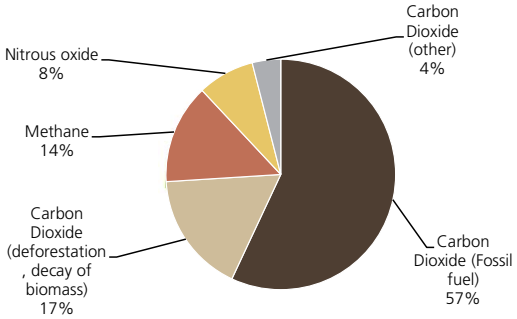
The originator: Burning hydrocarbon-based fuels (e.g. in the energy and power sector) is the largest cause of greenhouse gases, with about two thirds of total emissions (others are land use and forestry). The electricity/heat (main use is coal and natural gas) and the trans-

Fig. 1: Urbanization rates of selected countries
China has the fastest urbanization rate



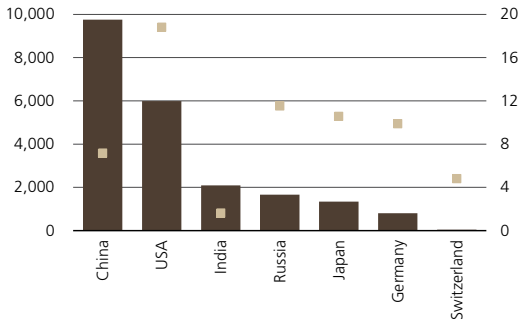
Source: United Nations - World Urbanization prospects: The 2014 revision

Fig. 2: Make-up of greenhouse gases
CO2 accounts for 78% of total greenhouse gases



Source: United Nations, as of 2014

Fig. 3 : CO2 emission by country in million tons and per capita in tons
China and the US produce the highest emissions globally; Russia and Germany produce the most emissions in Europe; Switzerland's level is very low



Source: BP Statistical Review of World Energy 2015. Note: CO2 emissions in million tons on left-hand side, per capita emissions per capita in tons on right-hand side

portation (main use is crude oil) segments (automobiles, trucks, ships, planes, etc.) are responsible for 42% and 23% of energy-related emissions; the rest are industry (20%), residential (6%) and others (9%). In terms of fuel type, more than 90% of emissions are from fossil fuels, with the highest contribution from coal (42% of energy-related emissions), oil (33%) and natural gas (18%).

The challenge: Global GDP is expected to treble by 2060, with most of the growth coming from emerging markets, according to the OECD. This means that total energy demand in general, and electricity demand in particular, will also grow strongly. The IEA estimates that 17% of the global population lacks access to electricity (about 1.2 billion people) and 38% lacks clean cooking facilities (about 2.7 billion people) today. These numbers indicate the growth potential of energy demand.

The consequence: There is controversy among scientists about the impact of climate change and the right way to reduce carbon emission. However, most scientists agree about the increasing frequency of extreme climate events, limitations to global food production due to reduced crop production, changes to the availability of water resources, rising sea levels affecting coastal cities or smaller islands and increasing health issues due to air pollution. Citi estimates that a 2.5°C increase in temperature will reduce global GDP growth by about between 0.7-2.5 percentage points.

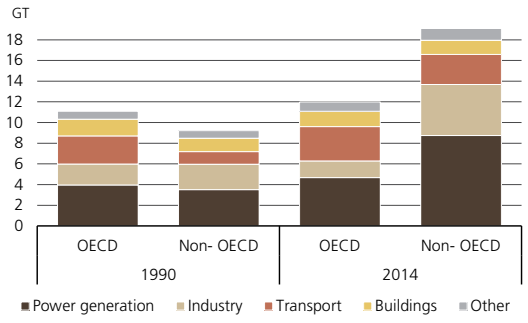
The solution: The 2015 UN Climate Change Conference (COP21) held in Paris has widely been seen as a "turning point" toward a low-carbon future. It resulted in the first-ever legally binding and universal climate deal. The 195 participating nations agreed to: 1) limit the global temperature rise to below 2°C (and further pursue efforts to limit the rise to 1.5°C); and 2) to limit and reduce carbon emissions as soon as possible. While further steps have to be taken (further signings, national ratifications, specifications, etc.), the agreement is due to enter into force in 2020.

The implications: Limiting the usage of fossil fuels will reduce greenhouse gas emissions the most. Coal is a boiler fuel used for significant power generation in many countries, like China, Germany and the US. A gradual transition to renewables and/or natural gas, which emits less than half of the emissions compared to coal, began years ago. The transport sector is the main user of crude oil products. We believe more efficient energy use of traditional engines and increasingly alternative powertrains (hybrids, plug-in, electric vehicles) will see strong growth rates. In particular, electric cars are set to play an essential role in de-carbonizing the road transportation sector. However, a meaningful shift in the away from high carbon-emitting fossil fuels may take decades. In the meantime, the energy/power production sectors will see drastic changes toward a cleaner fuel mix as well as clean-air technologies, and new energy efficiency solutions will transition the automotive, building or industrial segments.

Box 1: The two degree scenario

The two degree scenario aims to limit the global increase in temperature to a maximum of 2°C by reducing the concentration of greenhouse gases in the atmosphere to around 450 parts per million (ppm). This implies a 50% CO2 reduction by 2050 compared with 2009 levels. CO2 has a cumulative effect in the atmosphere, and our world has already spent 65% of its CO2 budget. Given that less than 1,000GT (gigatons) of CO2 capacity is left before temperatures rise irreversibly above 2°C and harm our climate, there is clearly an urgent need to reduce CO2 in a sustainable way.

Fig. 4: Energy-related CO2 by sector and region in gigatons (Gt)
Non-OECD countries emit 60% of global CO2



Source: OECD / IEA*, UBS
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The costs: The IEA estimates accumulated investments of around USD 36trn (see Fig. 6) or USD 2.3trn (see Fig. 19) per year in areas like clean-air technologies, energy efficiency or solution providers specializing in renewables between 2015 and 2030. This implies at least USD 10trn of additional investment compared to previous estimates.

Three scenarios for cleaner air and carbon reduction:

Achieving tangible results necessitates coordinating efforts to bring down emission levels worldwide. The Intended Nationally Determined Contributions (INDCs; see Table 1) form a good basis for establishing common ground for CO2 abatement. The Paris Conference is seen as a stepping stone for harmonizing regulations and elaborating scenarios toward global de-carbonization, with the following three scenarios provided by the IEA to foster clean air.

- **The INDC scenario** is our **base case scenario**. It posits keeping CO2 emissions stable at around 34 gigatons (Gt) annually until 2030 (see Fig. 5). Cost-effective solutions, such as emphasizing renewables and retiring inefficient coal plants, are being prioritized in the short run. In the long run, investment will target greater energy efficiency. This scenario anticipates around USD 36trn in cumulative investments, or 3-4% of annual spending growth, until 2030 (see Fig. 6).
- **The Bridge scenario** targets 4.8Gt more of annual CO2 abatement than the INDC by 2030 (see Fig. 5) and would cost more. It would require much greater energy efficiency and earlier retirement of inefficient fossil fuel plants (see Fig. 7). But even the Bridge scenario is not enough to prevent global temperatures from rising by more than two degrees by 2050, which is above the safe temperature level.
- **The 450 scenario** aims to cut annual CO2 emissions by an additional 9Gt compared to the INDC by 2030 (see Fig. 5). Incremental CO2 will be reduced through carbon capture and storage (CCS), greater energy efficiency and new technologies (see Fig. 7). China and India will have to significantly reduce their incremental CO2. Additional cumulative investment of USD 2.1trn will be needed to achieve the 450 scenario by 2030 (see Fig. 19).

Clean-air and carbon-reduction technologies to reduce emissions

With stricter and/or harmonizing standards, industries should be incentivized to opt for clean-air technologies. This is also evidenced by the increasing investment in renewables since 2014, given the commitment to them by a number of large countries, even in the context of falling oil prices and subsidies. There are several ways to de-carbonize the world in the short and the long term:

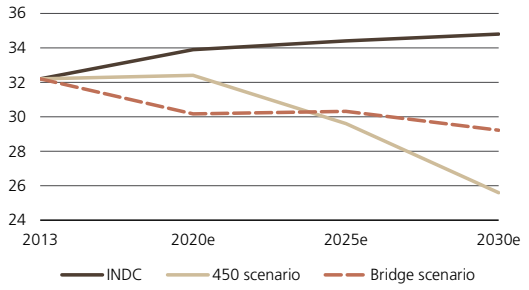
- In the short run, existing and proven technologies - including the phasing out coal plants, the use of renewables and the

Table 1: Intended Nationally Determined Contributions (INDC)

UNFCCC Party	Intended Nationally Determined Contribution
European Union	Reduce EU domestic GHG emissions by at least 40% below 1990 levels by 2030.
United States	Reduce net GHG emissions by 26% to 28% below 2005 levels by 2025
Russia	Reduce anthropogenic GHG emissions by 25% to 30% below 1990 levels by 2030 subject to the maximum possible account of absorptive capacity of forests.
Switzerland	Reduce GHG emissions by 50% below 1990 levels by 2030 (35% below by 2025)
Norway	Reduce GHG emissions by at least 40% compared with 1990 levels by 2030.
Mexico	Reduce GHG and short lived climate pollutant emissions unconditionally by 25% by 2030 with respect to a business-as-usual scenario.

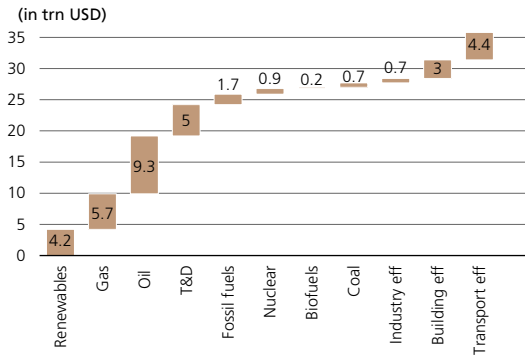
Source: UNFCCC. Note: GHG = greenhouse gas.

Fig. 5: CO2 abatement under 3 different scenarios
INDC, our base case, targets 34Gt of CO2 emission annually by 2030



Source: OECD / IEA*, UBS

Fig. 6: INDC scenario and 2015-30 investment
USD 35.8trn of cumulative investment 2015-2030 in the INDC scenario (in trn USD)



Source: OECD / IEA*, UBS; Note: T&D = Transmission & Distribution, Note: eff = efficiency

deployment of cleaner biofuels - should constitute a large part of the solution. Technological innovations that are also cost-efficient are the preferred way of doing so at least until 2020.

- After 2020, energy-smart technologies that emphasize energy efficiency, power storage, carbon capture and storage, and the use of bio-energy (bio-fuel, bio-gas, bio-mass) should play a central role. These technologies still need to be developed and incentivized via higher CO2 costs. In the transportation segment, a drastic change of the powertrain will lower the usage of crude oil.

1) Power generation mix shifting away from coal

Power plants are the most carbon intensive and generate 14Gt, or 42%, of total annual carbon emissions. The phase-out of inefficient coal plants is the fastest way to abate CO2, and coal-based utilities are likely to suffer the most from stricter regulations. However, given growing energy needs and the dominant use of coal in many countries, it will be a challenge to limit power production from coal plants. In the US, the Environmental Protection Agency (EPA) introduced the Clean Power Plan in August 2015 to reduce CO2 from fossil fuel power plants by 32% by 2030. Although President Trump has signed an executive order to rescind the Clean Power Plan, the low price of natural gas in the US is likely to continue to economically promote more electricity generation with natural gas, and less with coal in the US.

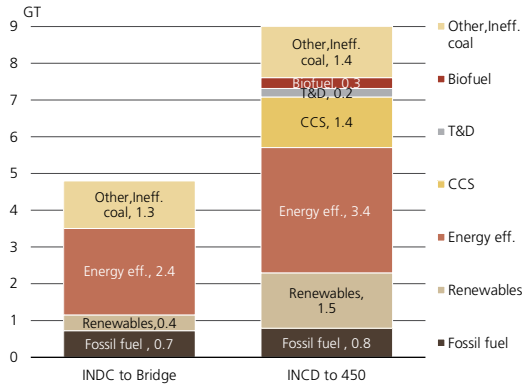
Some 70% of global power is generated from fossil fuels (mainly coal). The carbon intensity of primary energy sources could be reduced by using a cleaner fuel mix that includes biofuel and natural gas (which emits less than half of the CO2 that coal produces).

As regulations get stricter, industries and utilities worldwide are likely to opt for cleaner fuels, such as renewables and nuclear (especially in Asia).

Under the INDC base-case scenario, global utilities will need to retire 200 gigawatt (GW) of inefficient capacity out of the 1,200GW installed base within the next 15 years (see Fig. 8). A minimum of 400GW of incremental shutdowns would be required in the case of the Bridge and the 450 scenarios (see Fig. 8). Capacity would need to be retired mostly in emissions-heavy countries such as China, the US and Europe (especially Germany).

Market opportunity: The explorers and the producers of natural gas and liquefied natural gas are expected to benefit from the greater use of a cleaner fuel mix. Industrial gas companies active in coal-to-gas or industrials that produce combined-cycle gas turbines (CCGT) should also be rewarded from this trend. More than USD 16.7trn is likely to be invested in this area (oil, gas, fossil fuels) from 2015 to 2030 (see Fig. 6 and Fig. 19).

Fig. 7: Incremental CO2 reduction from INDC to Bridge scenario and from Bridge to 450 (in Gt)



Source: OECD / IEA*, UBS; Note: CCS = carbon capture and storage, T&D = Transmission & Distribution

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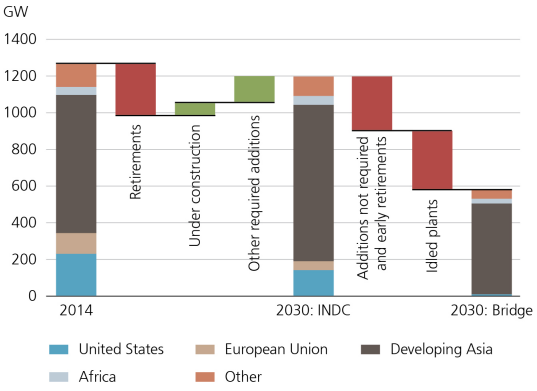
Fig. 8: Capacity changes of inefficient coal plants
200GW of capacity to be cut in INDC and incremental 400GW in Bridge scenario



Source: OECD / IEA***

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2) Renewables to play a central role in replacing fossil fuels
CO2 intensity can be reduced cost effectively now due to the progress made by renewable technologies. They are expected to play a central short-term role as they are accessible and easy to install. The EU's 2020 Strategy aims to cut greenhouse gas emissions by 20%, increase the share of renewables in its energy mix to 20% and achieve 20% energy-efficiency targets by 2020.

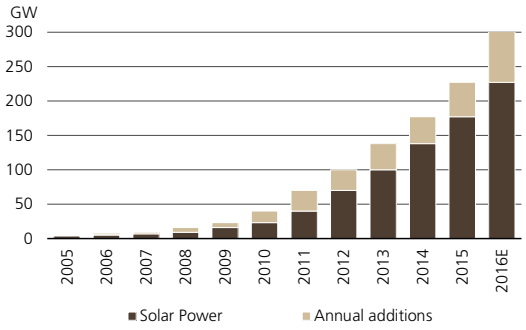
Overall, more than 130GW of solar and wind generating capacity was installed globally in 2016 (see Figs. 9 and 10) (note: generation capacity differs from power production), which represents half of the total energy-generation capacity addition. Hydro investment and geothermal added to total renewable capacity additions. Investment in renewables has multiplied sixfold in China and Europe over the past decade. We expect high growth in renewables in China, the US and the EU in the coming decades.

Rapidly declining costs have boosted the installation of solar photovoltaic (PV) cells. In a shorter time-frame than expected, PV cells became cost competitive with traditional coal/gas power generation facilities in certain locations, namely the US. Solar auctions in Europe (e.g. Germany and Denmark) also highlight the enormous cost decline. It is now competitive with retail electricity prices in many markets. 2016 was another record year for solar energy installations, with capacity growth of around 75GW. This lifted the global total solar PV market to about 300GW (see Fig. 9). However, we expect growth to continue thanks to expected price declines. UBS forecasts prices of solar modules will halve in the coming years. Thanks to lower costs, solar PV installations are expected to grow at low-teen rates in the next few years globally.

Globally, 55GW of wind power was installed in 2016. This was just short of the previous year's record additions and brought the total installed capacity close to 500GW (see Fig. 10). Asia-Pacific accounted for more than 50% (23GW were from China alone) of wind additions, while Europe and North America provided about 25% and 16% of global new wind capacity. China, the US and Germany were the countries with the highest wind capacity additions last year (see Fig. 11). **Onshore wind** has become cost-competitive with new conventional power plants, and its use is expected to expand 5-8% per annum over the next five years. Currently, the investment focus is also shifting to large **offshore wind** farms. However, offshore additions of 2.2GW in 2016 brought the total capacity to 14.4GW (about 90% of this was installed in Europe), which is a rather small share compared to onshore wind.

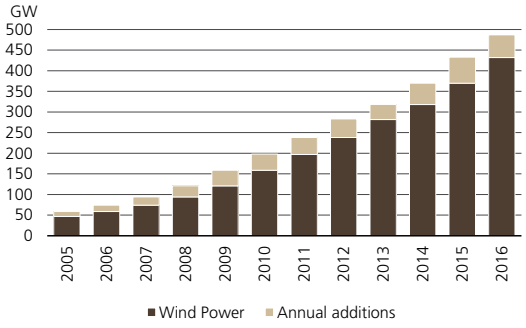
Market opportunity: Annual investment in renewables could rise from about USD 270bn in 2015 to USD 400bn in 2020. Total investment is expected to reach USD 4.2trn by 2030 (see Fig. 6 and Fig. 19). We see opportunities in companies specialized in solar PV cells, thin films, polysilicon, silicon wafers, smart solar modules, wind turbines, wind blades and specialty polymers.

Fig. 9: Global cumulative installed solar PV capacity 2005-2016 (in gigawatt - GW)
Growth has accelerated in the last two years



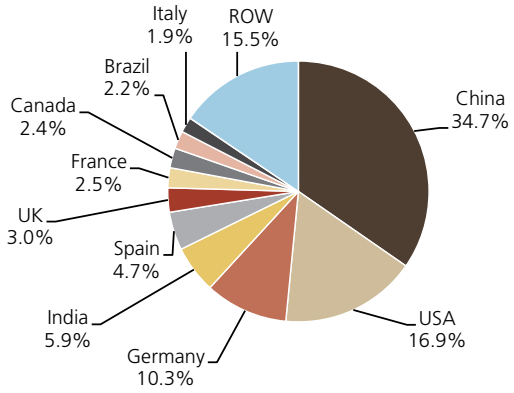
Source: REN21, UBS

Fig. 10: Global cumulative installed wind capacity 2005-2016 (in gigawatt = GW)
Constant strong wind power additions



Source: GWEC Global Wind Energy Council, UBS

Fig. 11: Share of newly installed wind capacity in 2016
China, the US and Germany with the highest additions



Source: GWEC Global Wind Energy Council, UBS

3) Electric vehicles - strong growth ahead

According to CEO and Chairman Mary Barra of General Motors, "the auto industry will change more in the next five to ten years than it has in the last 50." We think the electrification of vehicles is a major part of this change. While penetration is currently at low levels globally and innovation is at an early stage, we expect rapid growth of electric vehicles in the years to come. Of course, a disruptive technology change in an industry which is characterized by long-term product cycles, high investment and capacity requirements cannot occur overnight.

Following the success of the niche car Tesla Model S, the US car manufacturer unveiled plans for a near affordable mass market sedan, the Model 3, which the company plans to deliver by the end of 2017. Only three weeks after the unveiling, Tesla claimed almost 400,000 people had pre-ordered the Model 3. But it's not just about Tesla: most other premium and mass market car makers have also announced plans to launch innovative (partially) electric products, leaving the outlook for these vehicles bright. Daimler, for example, is developing a new electric vehicle brand and is targeting to electrify around 15-25% of its new cars by 2025.

Electric vehicles emit zero tail-pipe emissions, which is a strong sales argument for consumers and regulatory bodies. However, a higher penetration will raise demand for electricity. Moreover, it depends on a country's power generation mix whether an increased number of electric vehicles is beneficial for the environment and reduces emissions. For countries like France and Switzerland, which currently produce about 95% of their electricity from quasi-CO2 emission-free hydro and nuclear plants, the effect of reduced usage of oil products will lead to substantially lower emissions. On the other hand, in countries like China, Germany or the US (see Fig. 12), where power production from high carbon intensive coal has still a share of 73%, 42% and 33%, respectively, the positive effect of lower oil demand on greenhouse gas emissions should only accrue over time when coal is replaced by cleaner power production facilities.

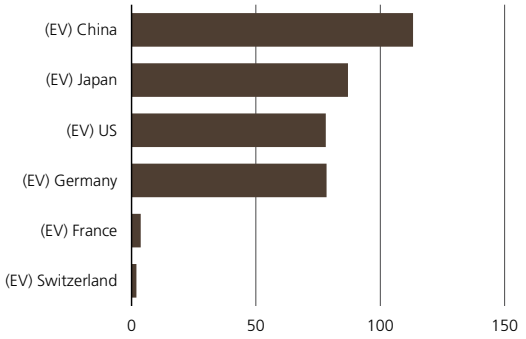
Market opportunity: Global car manufacturers and suppliers are expected to invest billions of dollars into the powertrain of the future. With the exception of Tesla, the share of electric vehicles sales (even if hybrids, plug-in, etc. are included) is still negligible for most companies. That said, we expect strong growth rates in the coming years and potential market share movement. Players along the electric vehicle value chain should be among structural beneficiaries from rising penetration.

4) Automotive efficiency and emissions-control technologies

Transport explains 23% of total annual carbon emission. The International Council on Clean Transportation estimates that the number of motor vehicles worldwide will rise from about 1.5bn currently to more than 2bn by 2020. About two-thirds of the world's daily oil output is consumed in the transportation sector (automobiles, trucks, ships, planes, trains, etc). Last year, light-duty and heavy-duty vehicles emitted in excess of 6.5Gt of CO2 out of the 32Gt total. In this

Fig. 12: Implied CO2 emissions per electric vehicle (gram CO2 per km)

Electric vehicles are not so clean in fossil fuel based countries



Note: After the Fukushima nuclear accident, the power generation mix in Japan has shifted away from nuclear to natural gas and coal, increasing the level of CO2 emissions. It is unclear if nuclear power production will increase again.

Source: UBS estimates

context, major economies have targeted reducing CO2 g/km by 30–40% by 2025.

Car makers will need to invest to comply with the regulations, while auto suppliers will benefit from increasing demand for the new technologies.

Along with adopting CO2-abatement measures, **developing markets** such as China, India, Mexico and Russia are expected to comply with low-sulfur fuel standards and tailpipe emission standards within the next five years. Desulfurization of heavy crude oil with the help of hydrogen is necessary to reduce sulfur (SO2) in the atmosphere. Low-sulfur-content gasoline and diesel could cut emissions of sulfate particulates, the main cause of premature death from respiratory illness.

Advanced economies such as the US and Europe have already adopted low-sulfur fuel and are generally focused on CO2 standards and emission controls (see Table 2). Europe has the objective of meeting its 95g CO2/km target by 2020–21. That said, CO2 standards apply to new motor vehicles only. More effort is needed to reduce pollution, apart from CO2, from existing fleets and especially heavy-duty vehicles. Technological advances in fuel efficiency, catalysts and filter use will be key here.

Running vehicles on **biofuel** can slash CO2 emissions by 30-70% compared to gasoline, while the use of cellulosic ethanol can reduce them by 90%. Moreover, the use of biofuel is well supported in the US as the Renewable Fuel Standard requires renewable fuel to be mixed into what's used for transportation. According to the IEA, the annual amount of biofuel is forecasted to rise from about 6m tons of oil equivalent (Mtoe) to 160 Mtoe by 2030.

Market opportunity: About USD 4.4trn is expected to be invested in transport-related efficiency and emission control technology in the next 15 years (see Fig. 6 and Fig. 19). Automobile suppliers should benefit from this trend. They provide sought-after technology to improve engine and transmission components, foster gasoline direct injection, light-weighting, lithium-ion batteries, turbochargers, components for powertrain electrification and low rolling-resistance tires. Older vehicles also need to be retrofitted, which increases demand for additional filters and auto catalysts. Ceramic substrates or particulate filters are likely to see greater demand. Furthermore, industrial gas companies provide hydrogen to desulfurize heavy crude oil. The way to invest in biofuel would be via enzyme and agrochemical companies, which improve the biofuel output.

Table 2: World class emission standard
Various emission standards get stricter

G20 Policy type	World class Emission Standard
Clean, low-sulfur fuel	10 to 15 ppm sulfur for gasoline and diesel fuel
	Euro 6 and Euro VI, US Tier 2/HD2010 or equivalent
Tailpipe emissions standards	Passenger vehicles: Euro 6 or US Tier 2
	HDD: Euro VI or US HD2010
Fuel economy and CO2 standards	Passenger vehicles: 95g CO2/km, or measures to cut new vehicle fuel consumption in half by 2030 from a 2005 baseline.
	HDD : measures to cut new vehicle fuel consumption by 35% by 2030 from a 2010 baseline.
Green Freight	HDD : measures that promote real-world, market-based performance improvements tracked through standardized and verifiable reporting mechanisms (e.g. SmartWay in the U.S and Canada)

Source: ICCT**, UBS Note: ppm = parts per million; HDD = heavy duty diesel.

** International Council on Clean Transportation; Policies to reduce fuel consumption, air pollution and carbon emissions from vehicles in G20 nations, http://theicct.org/sites/default/files/publications/ICCT_G20-briefing-paper_Jun2015.pdf).

5) Building and industry efficiency

Buildings account for 6% of the 34Gt of annual carbon emissions. Energy use is concentrated in water heating, lighting and space heating. Adopting energy-efficiency measures in these areas will be crucial to CO2 reduction. Building insulation has proven an extremely cost-effective and energy-efficient way of saving energy. Investment in cost-effective building efficiency should accelerate thanks to new and accessible technologies.

The industrial sector generates 7Gt, or 20%, of total annual carbon emissions. It consumes about 8.5% of global crude oil. The IEA recommends setting minimum energy performance standards for electric motor systems and adopting variable-speed drives.

This involves automation, controls, grid, smart grid, heat transfer, lighting, power distribution and generation, and renewable interconnections.

In IT, cloud computing, consolidation, data center design and operation, heating and cooling, power management and thin provisioning will all play a role.

Lighting accounts for 15-20% of global electricity consumption. Given that LEDs could reduce consumption by half, growing penetration would make a significant contribution to reduce electricity consumption. Energy efficiency measurements should remain high on the political agenda and so is the support for LEDs. Following average annual growth rates of about 30% over the past five years, a forecasted market share of around 50% in 2017 and a very short replacement cycle, LEDs could replace all installed lighting before 2030.

Market opportunity: In our basic INDC scenario, more than USD 3trn (see Fig. 6 and Fig. 19) could be spent to enhance building efficiency by 2030. Building automation, energy services, insulation materials and high-efficiency lighting are key to producing energy savings. The phase-out of inefficient refrigeration, cleaning appliances, televisions and computers is to be achieved by 2030 (see Table 3). For industry applications, the INDC scenario envisions USD 700bn of cumulative investment opportunity by 2030 (see Fig. 6 and Fig. 19).

6) Carbon capture and storage in the steel industry

Carbon capture and storage (CCS) consists of separating CO2 and transporting it via a pipeline to geological reserves. CCS could provide additional upside to our INDC base-case scenario. Indeed, the INDC and the Bridge scenarios do not include CCS to reduce carbon emissions, but the 450 scenario does. This could contribute an additional 1.2GT of reduction by 2030 if the technology is widely commercialized.

CCS technology could be deployed in various industries such as steel and power-generating utilities. CO2 pollution intensity per USD 1,000 of revenue is highest in steel (see Fig. 13 and Fig. 14), well above the utility and oil and gas sectors. In steel, CCS starts with an oxy-

Table 3: Energy efficiencies in residential and transport by 2030

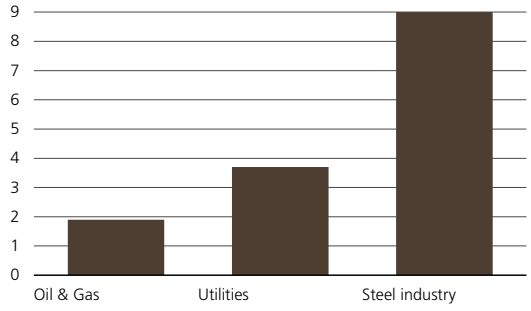
		Refrigerator (kwh/ appliance)	Cleaning equipment (kwh/ appliance)	Lighting (kwh/ m2)	Heating and cooling (2013=100)	Passenger vehicles (l/ 100km)	Heavy trucks (l/ 100km)
US	2013	720	375	9	100	6.8	46
	2030	485	265	5	32	3.9	32
EU	2013	305	255	4	100	5.3	30
	2030	220 (A ++)	235	2	29	3.4	21
China	2013	375	135	6	100	7.3	38
	2030	365 (Grade 3)	170 (Grade 3)	6	49	4.4	27
India	2013	365	135	5	100	6.1	40
	2030	335	170	5	73	4.1	28
South east Asia	2013	480	435	3	100	6.9	44
	2030	395	485	3	100	4.6	31
South Africa	2013	350	295	4	100	6.6	38
	2030	180 (A)	275 (C)	4	85	4.0	27

*Based on Energy and Climate Change – WEO Special Report © OECD/IEA 2015, IEA Publishing; modified by UBS AG. License: https://www.iea.org/t&c/

Source: OECD / IEA*, UBS

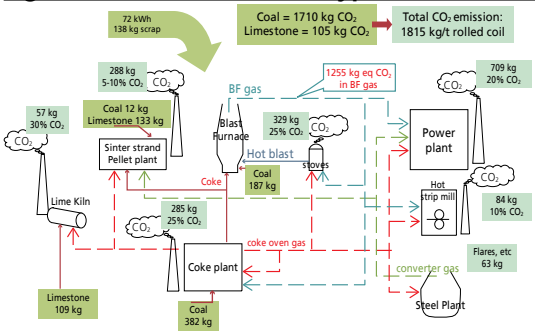
Fig. 13: CO2 in the steel industry (tons/USD 1,000 sales)

Steel industry emits more CO2 than power companies per unit sales generated



Source: United Nations, UBS

Fig. 14: CO2 emissions of a typical steel mill



Source: United Nations

combustion process (i.e. injecting oxygen and extracting the CO2), followed by carbon capture and storage. Combustion is enhanced by injecting oxygen as higher temperatures are achieved. Newer technologies use different systems, such as liquid ammonia scrubbing or membrane technologies.

The first coal-fired commercial plant with CCS was launched in Boundary Dam, Canada. It can capture 324 kilotons of CO2 annually. There are about 20 CCS projects under consideration. CCS remains costly and is still being developed. Industrial gas and energy companies are active in oxycombustion and carbon capture technologies, which are promising but expensive. The US and China could be attractive markets for the CCS technology, if the technology can prove economic to deploy.

Market opportunity: Our base case, the INDC scenario, does not envisage any investment in CCS, which only arrives with the 450 scenario. It adds an estimated USD 1.2trn worth of investment by 2030 (see Fig. 19), contributing around 15% of incremental total emission reductions (see Fig. 7). Of the cumulative investment, oil and gas exploration (mainly the service companies due to their technological know-how), energy pipeline transmission and industrial gas companies are likely to benefit from this trend.

7) Transmission and distribution and storage to support renewable growth

Grid interconnections, energy storage and smart-grid technology are necessary to efficiently use renewable-source energy. Connection to the grid, which requires infrastructure investment to link renewables to transmission and distribution lines across countries, presents the main challenge to renewables. As the number of new, efficient gridlines increase, electrical output is anticipated to rise and save electricity wasted in the transmission process. Storage and the smart use of renewable energy are essential to its widespread adoption. Electricity generated from renewables is volatile and depends on external factors (sun, wind). The lack of storage capacity to smooth out energy supply prevents investment in utility-scale capacities of renewables.

By 2035, battery prices could drop by 70%, which will enable greater storage and smarter use of renewable energy. This area of investment belongs to the renewables and energy-efficiency part of the 450 scenario, and provides additional upside to our INDC base case.

Market opportunity: In the INDC scenario, improved grid interconnections would require investment of USD 5trn by transmission and distribution companies (see Fig. 6 and Fig. 19). Transmission and distribution equipment suppliers and cable producers are expected to benefit from this trend. Regulated utilities that invest in their asset base are also likely to benefit from a higher return on these assets. Moreover, sodium-sulphur batteries, lithium-ion cells, lithium-ion batteries and battery storage systems will require more investment, but we will not explore these in detail at this stage.

Risks

The end of alternative energy subsidies and economic stimulus measures due to low oil prices could also dilute the theme. There may be short-term volatility if US Production Tax Credits (PTC) or Investment Tax Credits (ITC) are eliminated, given the large share of renewable capacities in the US. Despite the potential for short-term volatility, we believe the long-term trend of a more important role of renewables in the power generation mix remains intact.

Slower-than-expected cost declines for new technologies and the elimination of government development subsidies may also hurt solution providers. In case of electric vehicles, a significant reduction of battery costs will be required to enhance the affordability and electric vehicle (EV) penetration on the road. If solution providers can cut development and implementation costs faster, the adoption rate may speed up. On the other hand, rapidly advancing electric vehicle technology may lead to significant competitive dynamics, impacting investment decisions and move market shares of car producers and related manufacturers.

Political/regulatory risks and economic recessions present the main challenges to the theme. As politics remains in the driver's seat, a declining political focus towards climate change initiatives could be a headwind for the theme. They influence investment and the demand for clean-air and carbon-reduction technologies, and can affect the earnings trends of solution providers. If multilateral CO2 agreements are put in place, pollution costs will climb and companies will be forced to adopt new technologies. A lack of clarity about policies and regulations increases the risk of delayed investment, which may hurt the theme.

Link to sustainable investing

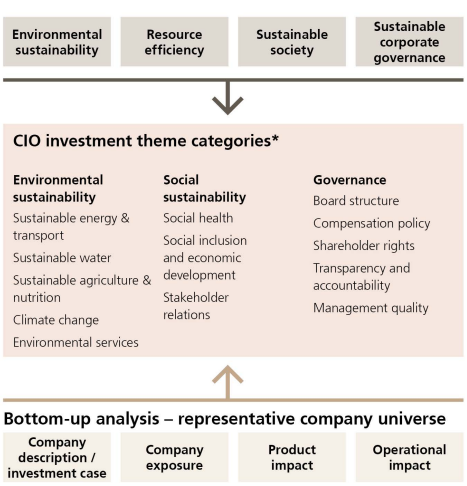
To identify whether a longer term investment (LTI) theme qualifies as a sustainable investment (SI) theme, we follow a two-step process. The first works top down. LTIs are assessed according to whether they match one or more of the sustainability topics within the environmental, social or governance (ESG) categories (see Fig. 15). In general, these themes must contribute to environmental sustainability (e.g. a low-carbon economy), resource efficiency (e.g. energy, water), a sustainable society (e.g. health, education, poverty reduction, equality and social inclusion, etc.) or sustainable corporate governance.

The second, bottom-up step consists of a thematically aligned representative universe of companies, a large majority of which (80% or more) must align with one or more of the ESG categories. For each individual company, a minimum business involvement threshold is applied; for example, 25% of revenues must derive from the thematic activity under consideration.

In the report, we discussed the underlying trends of our theme such as population growth and urbanization which are fueling the need for clean-air technologies. As shown by the 2015 Paris Climate Change Conference, politics is in the driver's seat. However, we also think several technologies are driving the structural energy transition where the usage of fossil fuels (especially coal and crude oil) will be reduced and substituted by alternative technologies (e.g. renewable energies in power generation, alternative power-trains in the automobile sector). We think our theme dovetails nicely with the SI thematic framework, addressing in particular environmental sustainability and resource efficiency.

Fig. 16 represents the global company average for MSCI ESG Research ratings that rank companies between AAA (best) and CCC (worst), taking into account various ESG factors.

Fig. 15: Overview of LTI topic clusters

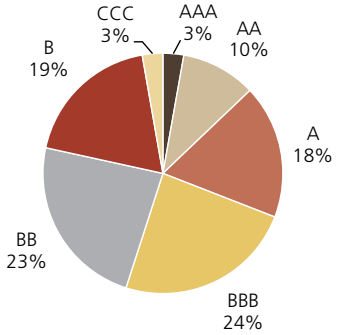


* For simplicity, all topic clusters include several subcategories not included in the graph. For example: sustainable water includes water utilities, treatment, desalination, infrastructure & technology, water efficiency and ballast-water treatment. Within each subcategory, there are further specifications; for e.g. water treatment includes filtration, purification and waste treatment. In total, we have more than 100 categories (potential sustainable investment themes) in our thematic database.

Source: UBS

Fig. 16: Entire MSCI ESG Research corporate coverage

Rating distribution in %, 5,720 companies



Note:AAA = best possible ESG rating; CCC = worst.

Source:MSCI ESG Research, UBS, as of 23 February 2017

Link to Impact Investing and the UN Sustainable Development Goals (SDGs)

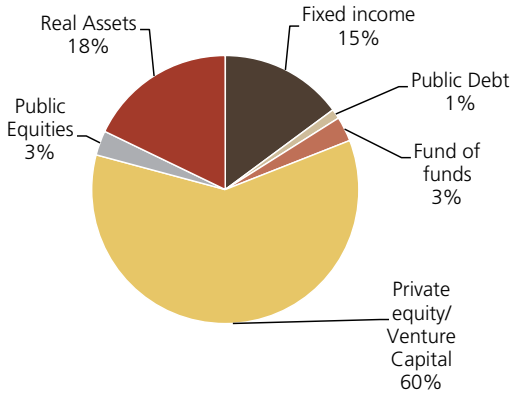
Goal 13 of the UN Sustainable Development Goals promises to "take urgent action to combat climate change and its impacts". Climate change will affect every country in every continent, but its worst affects will be felt by those in the global south, particularly sub-Saharan Africa and low-lying coastal nations.

Thankfully, as this paper has shown, affordable, scalable solutions are now available to improve air quality and reduce greenhouse gas emissions:

- 70% of the forecasted increase in emissions from developing countries is expected to come from infrastructure that has yet to be built. As more and more people continue to move from rural to urban locations, investing in green urban infrastructure now can help to ensure long-term, sustainable growth.
- Access to clean and affordable energy is Goal 7 of the UN Sustainable Development Agenda. Worldwide, 1.2 billion people, or about 17% of the global population, do not have access to electricity. This has important repercussions for human well-being and economic development. While increasing investments in renewables will be important for reducing emissions, equal attention should also be paid to grid interconnections, energy storage and smart-grid technology, particularly in markets where energy access is a problem.
- Increasing investments in energy efficient consumer products, such as efficient cooking stoves, can significantly reduce greenhouse gas emissions and prevent indoor air pollution which causes about four million premature deaths annually, particularly in Africa and Asia.
- Improving the fuel efficiency of industrial enterprises can significantly reduce global greenhouse gas emissions. Companies that invest in energy efficiency improvements, both within their own operations and via the products they sell, have been shown to outperform financially their less efficient peers. This presents numerous opportunities for impact investors, especially in emerging and developing countries, where scope for improvement is generally greater.
- Huge investments will be needed to bring new energy innovations from early-stage laboratory research to mainstream, commercial solutions. Investing in early-stage green technologies and clean-tech innovation can generate both significant financial returns and scalable impact.

Investing in clean air and carbon reduction solutions is both a global necessity and a significant market opportunity. Numerous impact investing solutions exist for investors looking to invest in this theme, primarily in private equity and venture capital funds (a rough breakdown by asset class of the impact investment fund universe in green technology and clean-tech is shown in Fig. 17).

Fig. 17: Breakdown of fund universe by asset class



Notes: Based on total number of impact funds in the Green Technology/Cleantech theme in the ImpactBase Database.
Source: GIIN ImpactBase, as of March 2017

In addition, investors may access this theme through generalist private equity and venture funds, renewable energy funds, or via direct investments. As always, when investing using non-impact-specific vehicles, impact investors must assess on their own whether individual investments meet impact criteria, including intent, measurability, and verification.

Nicole Neghaiwi, analyst

Investment conclusion

Clean air is a basic human need. Improving air quality has taken on the urgency of a global emergency, given the carbon accumulation in the air. Considering how quickly carbon emissions and other emissions are rising and their long-term effect on the atmosphere, it has become pressing for the UNFCCC climate conference in Paris to set the basis for multilateral agreements. We believe the need to improve air quality presents an investment opportunity for years to come.

There is no defined clean-air market, but we can assess its size based on IEA calculations and estimated investments needed by 2030. Extrapolating from the USD 1.6trn spent in 2014, annual investment in clean air products and services is forecast to rise gradually to USD 2trn by 2020 and USD 2.5trn by 2030 under the INDC scenario (see Fig. 18), which is also our base case scenario. This increase corresponds to 3-4% annual growth. Cumulative INDC investment is forecast to reach around USD 36trn by then and possibly around USD 38trn under the 450 scenario (see Fig. 19), which translates to mid-single-digit growth rates and more possible upside to the theme.

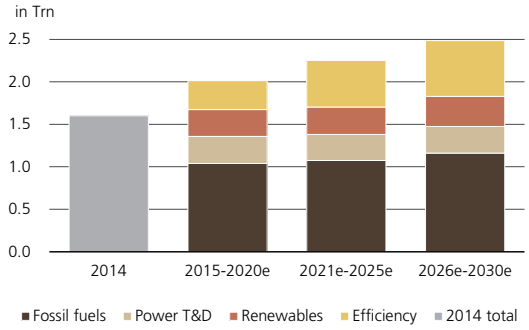
We see the greatest potential in:

- Renewable energy technologies, such as solar PV and wind as well as the needed infrastructure (electricity transmissions and distribution as well as energy storage);
- New technologies for the powertrain of the future in automobiles, including electric vehicles and hybrids; and
- Energy efficiency measurements in buildings and industrial applications, such as LEDs.

We expect good sales growth for this theme over the next two decades. As cost-effective new technologies are developed and efficiencies are realized, this theme should benefit from continued opportunities.

Fig. 18: INDC average annual investment 2014–2030

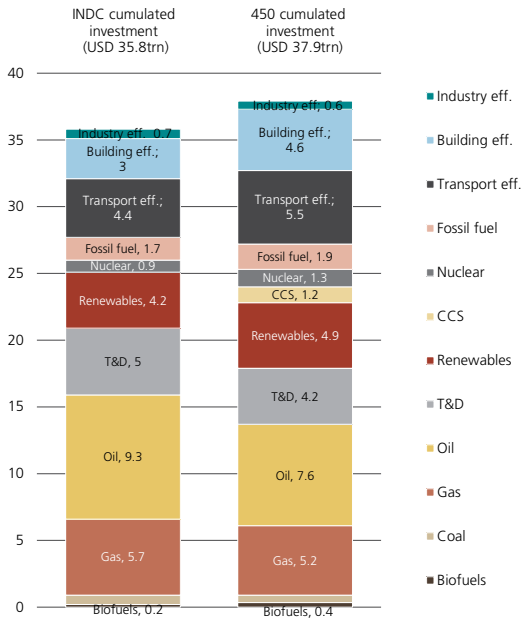
Investment to rise from USD 1.6trn to USD 2.5trn annually



Note: T&D = Transmission and Distribution. *Based on Energy and Climate Change – WEO Special Report © OECD/IEA 2015, IEA Publishing; modified by UBS AG. License: https://www.iea.org/t&c/

Source: OECD/ IEA*, UBS

Fig. 19: 2015–30 cumulative investment under INDC and 450 scenarios



Note: T&D = Transmission and Distribution

Source: OECD / IEA*, UBS

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Appendix

Terms and Abbreviations

Term / Abbreviation	Description / Definition	Term / Abbreviation	Description / Definition
A	actual i.e. 2010A	bp or bps	Basis point or basis points (100 bps = 1 percentage point)
COM	Common shares	E	expected i.e. 2011E
EV	Enterprise value = market value of equity, preferred equity, outstanding net debt and minorities	GDP	Gross domestic product
Shares o/s	Shares outstanding	UP	Underperform: The stock is expected to underperform the sector benchmark
CIO	UBS WM Chief Investment Office		