Climate Change
Global

HSBC Climate Change

HSBC Global Research

Sizing energy efficiency investment

USD365bn between buildings, industry and transport

- **At USD 365bn, investment in energy efficiency represents c1.5x investment in renewables**
- **Buildings offers the greatest opportunity with a value of USD271bn**
- **We expect tighter regulation and carbon constraints to increase opportunity**

Valuing investment flows

Global markets for energy efficiency remain relatively under assessed, with only fragmented overviews of total market size. The complexity lies in determining 'efficient' within energy intense sectors (buildings, industry and transport), while the lack of timeliness of data compounds the problem. This report presents a detailed breakdown of current investment spend in different segments of the energy efficiency value chain, namely in industry, buildings and transport. Crucially, our analysis focusses on identifying 'improvement': it separates the value of components (heat pump, electric engine, superior glazing) that deliver improved energy efficiency. This approach enables us to precisely pinpoint the value of the opportunity in the areas that most need to be accelerated to deliver a low carbon economy. For instance, the study finds that residential new build investment flows are 3.5x greater than non-residential new build. The results are based on analysis carried out by Ecofys for the HSBC Climate Change Centre of Excellence.

Our sister report 'Investing in energy efficiency', highlights HSBC's favoured plays in relation to energy efficiency. We believe scaling up energy efficiency remains an obvious high-impact low-cost choice to help reduce emissions, but energy efficiency dynamics change the outlook for utilities. HSBC analyst Adam Dickens looks at this in '*Power Struggle: Environment versus affordability*', 13 March 2013. The opportunity of optimising economic growth in relation to energy use is nowhere near realised in our view. While Germany is a country outlier that passed peak energy consumption decades ago (1979), the vast majority of countries would do well to step up efficiency efforts. We expect more capital specifically allocated to energy efficiency to be provided through green bonds.

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Summary

- We assess investment in energy efficiency improvement in the power hungry sectors of buildings, industry and transport
- The largest sub categories, at USD72bn are insulation and improved energy performance in the buildings segment
- Continued demand for energy efficient goods and services is underpinned by decarbonisation, pollution and security goals

Improving energy use

The global energy system is still primarily based on fossil fuels. Ensuring an affordable and secure energy supply which can support sustainable growth, while reducing emissions is the aim for most policy makers, but securing affordable short-, medium- and long-term supply while limiting environmental impacts is challenging. In addition, the demand challenges of finding the energy requirement to power improvement in living standards and lift people out of poverty are well known. Energy efficiency is widely recognised as the most appropriate tool available to achieve these goals.

In this report, we set out global investment in energy efficient products and services. We have identified the specific technologies and equipment relating to raising the bar on energy efficiency in different segments of the buildings, industry and transport sectors. Our analysis provides a comprehensive snapshot of the investments in the energy efficiency sector in 2012. We include, by market segment and by technology, all capital expenditures, mainly by final energy users, (both retail consumers and industrial entities) in the purchase of energy-efficient equipment.

Our analysis takes into account those technologies that are perceived by the market as energy-efficient today. In general, this means that the particular market has a less efficient alternative with significant market share, and there is usually a cost differential. Our assessment of investment will therefore yield significantly different results in the future, despite maintaining consistent methodology because products that are best-in-class today might be middle of the road tomorrow.

Our analysis identifies and separates the value of the components (heat pump, electric engine) that are delivering improved energy efficiency. The identification of 'improvement' is the crucial point here. For instance, we capture the value of the part that delivers improved efficiency in an 'A' rated tumble drier versus a 'D' rated one, not the value of the tumble drier itself. In our view this approach enables us to pinpoint precisely the value of the opportunity in the areas that most need to be accelerated to deliver a low-carbon economy. The results are summarised in Table 1 below.

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Table 1 – Breakdown of investment by sector in 2012

Subcategory/sector	Measure/technology	Total (USD bn)	Range (USD bn)	Comment
New Buildings				
Residential - New dwellings (envelope only)	Basic energy performance	39	35 - 45	Residential new build investment flows are 3.5x greater than non-residential new build
	Improved energy performance	49	42 - 56	
	Near zero-energy buildings	<<1	0 - 1	
Non-residential - New buildings: (envelope only)	Basic energy performance	10	7 - 12	In the buildings envelope, the improved performance category dominates at USD64bn
	Improved energy performance	15	8 - 34	
	Near zero-energy buildings	<<1	0 - 1	
New Build Total		**113**		
Renovation				
Residential - Renovation	Glazing	30	25 - 45	Renovation is the largest category in buildings at USD148bn
Non-Residential - Renovation	Glazing	7	5 - 15	
Residential	Insulation	65	55 - 90	Insulation is the largest segment at USD69bn
Non-Residential	Insulation	3	1 - 5	
Residential	Heating equipment	31	23 - 35	Residential renovation totals USD126bn versus USD22bn for non-residential
Non-Residential	Heating equipment	12	9 - 14	
Renovation Total		**148**		
Appliances	Appliances	3	1 - 7	Appliances and lighting represent 3.7% of building sector flows
	Lighting	7	5 - 30	
Buildings & Appliances Total		**271**		
Passenger vehicles	Improved efficiency	14	10 - 20	Almost 3/4 of investment in energy efficiency in transport is in passenger vehicles
	Of which: start-stop technology	4	3 - 5	
	Hybrid	5	3 - 7	
	Electrical (plug-in hybrid and full electric)	1	1 - 2	Innovation has been driven by emission standards
	Electric infrastructure	<<1	0 - 1	
Freight vehicles	Light duty vehicles and medium trucks	5	3 - 8	
	Heavy trucks	2	1 - 4	
Aviation and marine transport	Overall investments	<1	-	
Transport - total		**27**		
Industry	Motors	4	2 - 6	Site specific optimisation is a key driver for industry
	Variable Speed Drives	29	14 - 28	
	Investments in heating efficiency	23	19 - 31	
Industry Total		**56**		
Other	Agriculture, fishery and forestry	8	4 - 16	
	Combined Heat and Power	3	1 - 6	
Other – total		**11**		
Total		**365**	330-410	

Source: Ecofys

Energy efficiency improvement comprises a wide range of measures that differ from sector to sector, region to region and service to service, creating challenges for identifying value. Valuing the market is nonetheless worthwhile since it assists with channelling capital flows towards opportunities that deliver policy initiatives.

The global economy more than doubled (115%) from 2002 to2012 but energy supply grew by only 30%. This decoupling of economic activity from energy consumption means that each billion of global GDP required almost 40% less energy in 2012 than it did in 2002. This is good news, but in reality extending the carbon budget (see 'Investing within a carbon budget', 30 September 2013) means speeding up efficiency gains. We expect further regulatory drivers to provide the necessary prod.

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Most value is in buildings

Buildings and appliances have the largest representation at more than three-quarters of total investments at USD271 billion, with residential investments the bulk of the share. Much of this is for improving the building envelope (façade, roof, windows) by insulation and double glazing.

In buildings, renovation is a larger market than new build. The need to increase retrofit rates of existing buildings is widely acknowledged, but incentives in general are still weak. In other sectors, we expect energy and CO_2 performance standards to lead to higher volume sales of more efficient products. In this analysis most investments are in OECD countries, except for those in the industrial sector, where investments in Asia, most notably China are significant.

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Defining the market

- We identify the energy intense features of the buildings, industry and transport sectors
- We value the components and products that provide energy efficiency improvement
- Methodological challenges include regional differences in standards, evolving best in class and data availability

What is energy efficiency?

Energy efficiency is a productivity metric generally measured as the amount of energy needed per unit of services, e.g. the litres of gasoline needed per car-kilometre, the energy needed for the production of one tonne of steel, or the energy needed to heat a square meter of floor space. Here, we are focussing on measuring the market for energy efficiency improvement. That means determining values for products that reduce the amount of energy used per unit of services, provided that the type and quality of the services stay more or less the same.

This analysis does not place values on the energy that could be saved in other ways, such as through reducing the level of activities (e.g. driving less by car or closing production facilities to save energy) or moving to alternative options e.g. by replacing primary steel by secondary steel, or moving from car to train transport.

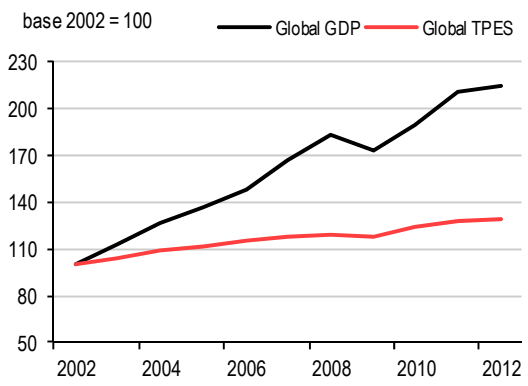
In our analysis, the definition of investment captures the value of the energy efficiency premium or discount for improving energy efficiency of the product or service. This approach enables us to pinpoint precisely the value of the opportunity in the areas that most need to be accelerated to deliver a low-carbon economy.

Currently, global markets for energy efficiency remain relatively under assessed, with only fragmented overviews of total market size and aggregations with little sector or technology segmentation. This compares poorly to other low-carbon industries like renewable energy for instance, where comprehensive investment updates are regularly published.

Improvements are under way

Energy supply grew by 30% between 2002 and 2012 but the global economy more than doubled (+115%) over the same period as shown in chart 1. This decoupling of economic activity from energy consumption means that each billion of global GDP requires almost 40% less energy in 2012 than it did in 2002. This is to a large extent the result of greater energy efficiency in the three key sectors - buildings, industry and transport - but it is also a result of changes in economic structure, e.g. from manufacturing to services.

Chart 1: Global primary energy supply and GDP growth

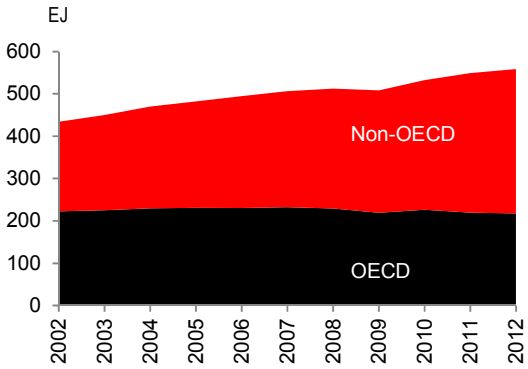


Source: IEA [4], BP [5], IMF[7] – see references sections for details

Quantification unlocks opportunity

Global energy consumption is still on the rise. In 2012, primary energy demand was 560 EJ, having grown by 30% since 2002. Incremental growth has come from non-OECD countries, as shown in chart 2 below.

Chart 2: Global primary energy consumption



Source: IEA

Our comprehensive quantification of global investment in energy efficiency highlights the potential opportunity set and gives an indication of the contribution of energy efficiency sectors to the economy. We provide a detailed snapshot of the investments in the energy efficiency sector for 2012. We include all capital expenditures, mainly by final energy users, (both retail consumers and industrial entities) in the purchase of energy-efficient equipment. We identified – per market segment and per technology – the volume of sales and the specific prices to generate a value for total sales volumes.

In some sectors, where saving energy use is important but where there is a high diversity of energy efficient options, such as industry and agriculture, it is not always possible to identify individual values. For these we estimate values based on the volume of energy saved and the average investment per unit of energy saved.

Methodological challenges

It is difficult to use consistent methodology across sectors to calculate investment flows because of regional differences on the interpretation of energy efficient, product technological change and an assessment of which part of the product or equipment to value. As a broad rule of thumb in all segments we regard a product as energy efficient if there are still products with a lower efficiency that have a significant market share.

Regional variation

Opinions of what constitutes energy efficient vary significantly on a geographical basis. For instance, in the building segment analysis we have included 'Basic performance buildings' as an efficient category, which is a valid approach on a global scale. However, in Europe 'Basic performance' is the norm and is regulatory driven.

Here today, gone tomorrow

Sizing the market is evolutionary and the same methodology could yield significantly different answers from one year to the next. What is best in class today is middle of the road, or even bottom of the class tomorrow. For example, in the European Union, fridges with a B-label were considered very efficient around 2000, in contrast to the fridges with D-labels or lower that dominated the market at that time. Now, most fridges in EU shops have an A+ label or better. Indeed from 2014 onwards refrigerators below A+ will be banned from the EU market, highlighting that the previous best in class is now obsolete. It is therefore important to note the assessed time frame.

In our analysis we take into account the technologies that are (still) perceived as best in class energy-efficient. In general, this means that the market still has a less efficient alternative with significant market share, and which costs less. To what extent this holds was determined on a case-by-case basis, but it is worth reiterating that what is regarded as energy efficient will always be a moving target.

Product, component, or process?

Second, assessing the part of the product or value chain that should be considered efficient can be open to debate. In some cases this is clear. For instance, a compact fluorescent lamp (CFL) can be completely considered as energy-efficient equipment. The situation is more complicated where the energy efficient equipment is a specific component included as part of a larger system or appliance, for example a heat pump in a tumble drier, or an electric engine in an electric car.

In addition there are different classes within product groups which muddy the waters. For instance it is more efficient to buy a light-weight car instead of an SUV, so should smaller cars be included? Or a smaller television? Furthermore labelling can even have a perverse impact when products are given a rating based on energy efficiency rather than consumption, so that manufacturers produce more efficient but bigger potentially more energy consuming appliances.

For our analysis we focus on the additional costs of an efficient product within a certain class (e.g. weight, size). It is possible to define a broader scope, however it would require more data and analysis and might even result in misleading values (smaller cars and televisions are generally cheaper than larger ones).

Mind the data gap

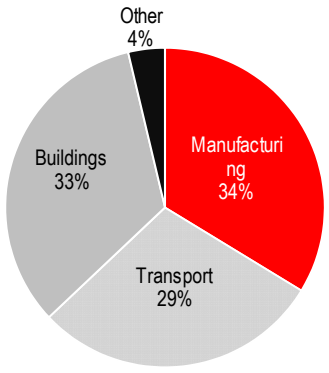
In addition to the methodological challenges highlighted above, data availability is sporadic at best, which leads to variation of analysis between sectors. However, even if more detailed regional and market data were available, it is not always sufficient. For example heat-exchangers and heat-pumps are used in all refrigerators and air-conditioners, but might also be applied to re-used heat in industrial processes.

Another data difficulty is an assessment of service provision in relation to particular aspects of energy efficiency, e.g. the re-design and re-engineering of industrial installations. This is partly captured by our estimates on realised energy savings, but is by no means exhaustive.

Which sectors are included?

Our analysis focuses on the most energy consuming sectors on a global framework which are buildings, industry and transport, as shown in chart 3. The other category comprises agriculture, forestry and fishing.

Chart 3: Sectoral breakdown of final energy consumption



Source: IEA [4]

Final energy consumption in every sector is currently dominated by energy from fossil fuel sources, although there is a rapid growth of renewable energy in many countries. Fuel use accounted for around 78% of all energy consumption in 2010, although this share has declined by nearly 2% since 2000 as electricity becomes a growing source of energy, accounting for 19% of the total. This is most evident in industry and buildings which both experienced a

39% growth in energy demand from electricity between 2000 and 2010. Penetration of electricity in the transport sector remains minimal, accounting for only 1% of transport energy use.

Our approach by sector

We believe that the most robust methodology is to focus on the identification and separation of the value of the components (heat pump, electric engine) that are delivering improved energy efficiency. Improvement is the critical factor here. We can classify the value of improvement as the "efficiency premium" and this is represented by the individual parts, not the total equipment. For instance, we would capture the value of the part that delivers improved efficiency in an A rated tumble drier versus a D rated one, not the value of the tumble drier itself.

As a general rule our analysis looks at the cost of those parts within a product that make it energy efficient, for example a start-stop system in a car, or a heat-pump in a washing machine. However, isolating costs for particular components or parts is not always feasible. For cases where this is not possible, our approach is to look at the cost-premium compared to less efficient products.

Buildings

In the buildings segment we calculate the value of global investment in relation to the buildings envelope (façade, roof, insulation and glass), heating equipment, and appliances.

For each part of the envelope we calculate investment on a regional, residential and non-residential and grade of efficiency basis. Regionally we split the analysis by OECD and non-OECD countries. The categories of the building envelope efficiency are basic, improved, and near zero performance.

The most recent data on the global number of buildings is for 2010. To determine the buildings stock for 2012 (the year of our assessment) we have looked at studies of OECD and non OECD building stock growth rates to make our own growth rate assumptions by region from 2010 to 2012. We assume growth of 1.2% for OECD and 4.5% for non OECD.

Building envelope efficiency is typically measured by a kWh/m^2 figure, which indicates the amount of energy that a floor will transmit. For buildings this represents how much heat/ cold from the inside will be lost to the outside and how much cold/heat will be let in. Therefore a high figure indicates poor efficiency. Four categories of building envelope efficiency can be defined, as follows (the numbers in brackets are only applicable to temperate climate zones):

Standard non-insulated buildings (>150kWh/m2): Dwellings without façade or roof insulation and basic (non-insulated) windows.

Basic performance (75 – 150 kWh/m^2): Dwellings with basic insulation and simple double glazing.

Improved performance (20-75 kWh/m^2): These dwellings have significant façade and roof insulation and well-insulated glazing.

Near zero performance (<20 kWh/m^2): sometimes also called 'passive houses' are very energy efficient and built according to strict requirements for insulation of façade, roof and windows.

We include basic, improved and near zero performance in our analysis. Even though in most OECD countries basic insulation has been standard building practice for several decades, we argue that for non-OECD an upgrade from standard to basic is significant and we want to provide continuity of methodology between regions.

In this analysis we also estimate investments in energy efficient heating equipment in OECD

countries. We include condensing boilers, air-to-air heat pumps and ground-sourced heat pumps. Our estimates also include an assessment of variable costs such as the labour required to install energy efficient products.

The buildings category also features appliances and lighting. For appliances we include refrigerators/freezers, washing machines, dishwashers, tumble driers (heat pump) and air conditioners and focus on products that perform better than minimum requirements. For both appliances and lighting we calculate the cost of replacing products to a higher efficiency standard. We do this by identifying product market volumes and assessing the cost of upgrade. Sales figures by efficiency class were unavailable for many regions, but we think that collecting more data on appliances would have only a limited impact on the total global investments in energy efficiency.

Industry

In industry, we look at the investment spend on motors, variable speed drives (motors that are particularly energy efficient because of the ability to reduce or increase speed relative to the demand for power) and industrial heating efficiency. Our investment values are based on the cost premium for high efficiency class motors and are similar to our replacement cycle analysis used for appliances. For motors we have included low and medium voltage. We consider variable speed drivers to be 100% energy efficient, so look at the size of the market to derive our motors analysis.

To measure the value of investment in industrial heating efficiency we ascribe a value to energy saved across industry. This is because there is not enough data granularity to complete a bottom up analysis of the components. Measures are in many cases are site specific and are incredibly diverse.

Transport

In transport we include vehicles, ships and aircraft. We identified three categories of energy efficiency options in vehicles: improved energy efficiency (of internal combustion engine cars), hybrid vehicles and electric vehicles (including both plugin hybrid vehicles and full-electric vehicles).

In the next chapter we present the results.

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Sector results

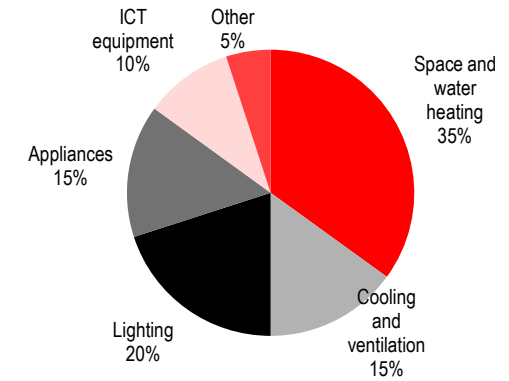
- Energy efficiency investment across buildings, industry and transport totalled USD365bn in 2012
- Buildings dominate, with renovation the largest sub-segment
- In industry site specific optimisation is key and in transport ¾ of improved efficiency investment is in passenger vehicles

USD271bn in buildings

1.7bn buildings worldwide

According to our estimates, the number of buildings in the world was approximately 1.7bn in 2012, with around 0.5 billion in OECD countries and 1.2 billion non-OECD. These figures include residential and non-residential (public, commercial, other) buildings, and account for around one third of global energy use. Most energy used in buildings is taken up in space and water and heating and in cooling and ventilation, as shown in chart 4 below.

Chart 4: Energy use in buildings



Source: DoE, LBL

We estimate that investment in the building envelope, appliances and lighting reached USD271bn in 2012, with table 2 below demonstrating the investment flows by sub-category.

Table 2: Breakdown of investment flows in the buildings sector

Subcategory / Sector	Energy rating / Technology	Value USD bn
New Buildings		
Residential (envelope only)	Basic	39
	Improved	49
	Near zero	<<1
Non-residential (envelope only)	Basic	10
	Improved	15
	Near zero	<<1
New build total		**113**
Renovation		
Residential	Glazing	30
Non-Residential	Glazing	7
Residential	Insulation	65
Non-Residential	Insulation	3
Residential	Heating equipment	31
Non-Residential	Heating equipment	12
Renovation total		**148**
Appliances	Appliances	3
	Lighting	7
Total		**271**

Source: Ecofys estimates

The key takeaways are:

1) Investment in renovation is the largest category at USD148bn, with insulation the bulk segment

2) Investment flows in residential new build are 3.5x greater than for non-residential new build

3) Within renovation, residential glazing, insulation and heating equipment totals USD126bn compared with USD22bn for non-residential

4) Within the buildings envelope, investment in the improved performance category dominates at USD64bn

5) Appliances and lighting represent just 3.7% of overall investment flows

Building envelope dynamics

In virtually all OECD countries, and also in many non-OECD countries, building codes have been implemented that require minimum levels of energy performance for new build. For instance, in the OECD most building codes already require basic insulation of the building envelope resulting in taking measures such as simple double glazing and a moderate level of insulation (typically up to 10 cm in temperate climate zones).

However, at the aggregate level, investments in optimum efficiency 'near zero energy' buildings are small, at less than USD1bn. These buildings typically reduce the energy demand for space heating by over 90% compared with the non-insulated situation. The additional costs for these dwellings are quite substantial (about 10% of the standard dwelling costs), which is one reason why so far the take up is low. Germany is the global leader, with its voluntary passivhaus standard already certifying buildings that achieve near-zero energy performance, but even in Germany the penetration rates are low. Other countries that have near zero performance buildings are Austria, the UK and the US.

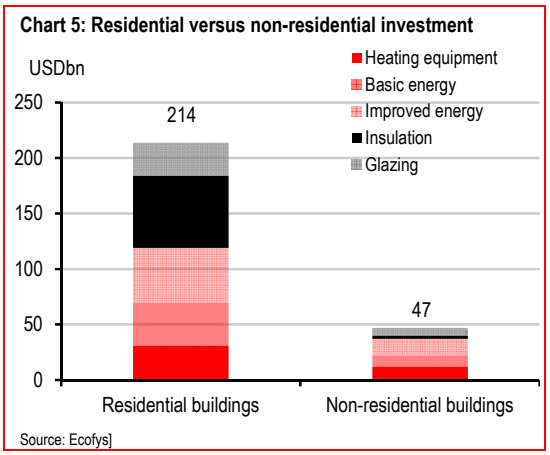
The energy performance of existing buildings can be improved by adding insulation to the roof and the façade, and thicker glazing. As this can lead to (sometimes drastic) changes in the building structures, this is often combined with renovations. Windows are typically a weaker point in the building envelope, with traditional single glazed windows providing poor insulation.

The market for insulation is also standards driven. More stringent building codes that mandate improved insulation are in place in Japan, most major countries in the EU, and about one third of the US. Building according to these stricter codes typically reduces energy demand for space heating by 75% compared with non-insulated buildings and requires higher insulation thicknesses, advanced glazing (argon-filled, low emissivity coatings) and additional equipment – like condensing boilers or heat pumps – and ventilation heat recovery. The market for insulation is strongest where the climate is coldest and energy prices are highest, therefore Northern Europe, Asia and North America, are major markets for insulation materials. More than 90% of insulation investments are made in OECD-countries.

Retrofit activity is still very much connected to the regular maintenance and renovation cycles of buildings, although several countries have some forms of stimulation in place to increase retrofit rates and incentivise energy efficiency measures independent of maintenance work. The retrofit segment is also dominated by residential buildings, which account for 85% of the total, while non-residential (public and commercial) buildings account for only 15% of the total.

Both new-build and retrofit investments have focused on improving the quality of glazing, moving to double or triple glazed windows and other advanced glazing technologies.

Most investment is made in the residential sector, as demonstrated in chart 5 below. The chart also highlights the value of renovation to the residential segment.



The market for efficient condensing boilers is dominated by European countries and consists of 12.5 million units with a total value of USD31 billion. The market is dominated by the European countries. In recent decades sales have been growing rapidly, mostly replacing less efficient non-condensing boilers. Roughly one-quarter of efficient boilers are placed in new buildings, the rest replace heating equipment in existing buildings. For residential buildings, the additional (the premium compared with non-condensing boilers) investments in efficient boilers for 2012 is USD12 billion, according to Ecofys.

Heat pumps come in a great variety of types and sizes, ranging from small air-to-air heat pumps for single rooms in private homes, to large-scale ground source heat pumps for entire office buildings. Ecofys estimate that total investment in heat pumps is USD17 billion and is included in the heating equipment category of table 2 above, of which 90% is in air-to-air heat pumps and 10% in ground source heat pumps. The largest national market for air-to-air heat pumps (used for heating and cooling) is Japan, which is responsible for close to three-quarters of the global market. The rest of the market is almost equally divided between the US and the European Union. In the US, the market for air-to-air heat pumps has grown by an average of 2.3% per year over the last decade.

For ground-source heat pumps, the European Union is the major player with the largest markets and number of installations found in Sweden, Germany and France.

The heating equipment category also includes district heating, which is concentrated mainly in Europe and is considered quite expensive. This is because these projects are often large and include many buildings per project, and that the costs typically accrue upfront to developers as an immediate cost, while the benefits are to residents and/or society over the whole building or network lifetime. In the heating equipment category for non-residential we also include an estimate for the market (revenues) for Building Energy Management Systems – which is estimated at USD1.8 billion.

In the lighting category the emergence of, first, compact fluorescent lamps (CFLs), and more recently, LED lamps resulted in something of a revolution in the global lighting market, away from incandescent lamps. Policy has also targeted the low hanging fruit of energy savings from simply changing bulbs: In more than 30 countries incandescent bulbs are now either being phased out or restricted, and/or energy performance labelling of lamps is being introduced. This has rapidly created a major global market for efficient lamps. We calculate investments relating to energy efficiency at USD7 billion.

Investments in energy efficient appliances are small in the context of the entire building sector. In the last 20 years most OECD countries have introduced minimum energy performance standards and energy marks or labels on a range of domestic and commercial appliances to improve their energy efficiency and environmental performance, and also to support consumers to purchase these technologies. The success of these programmes in the EU, US, Japan and others is being emulated around the

world with examples of energy labels in countries such as the Philippines, Ghana and Chile. Continued expansion of policies to new countries, and review and revision of existing policies, along with continued innovation and competition by producers on energy performance, is likely to push further growth in this market, although it is worth remembering that an efficient product is a moving target over time.

We expect to see a gradual spreading (geographical) and tightening of building codes. In the coming years more OECD countries will move from the basic to the improved energy performance level. The European Union has already decided to go further, legislating for the near zero-energy building as standard for all new buildings by 2021. This will not only lead to a larger market for insulation and triple glazing, but also to growing markets for heat pumps and heat recovery systems. Tightening and enforcing building codes in non-OECD countries could strongly add to this development.

It is widely acknowledged that increasing retrofit rates of existing buildings is important, especially for OECD countries. However, it is uncertain whether this will be sufficiently incentivised. In some countries, such as the UK, mandatory requirements for energy efficiency measures in existing buildings are expected. Furthermore, a recovery of housing and real estate markets could strongly add to growth in this sector.

More and more countries are phasing out incandescent lamps. Also energy performance standards for appliances are proliferating and being tightened. Although this may lead to larger volumes, the increase in sales in monetary terms may not be that strong. This is owing to learning effects that make new products progressively cheaper and, especially for efficient lighting, the longer lifetime of the products requiring less frequent replacement.

USD 27bn in transport

In 2012, 60 million new passenger vehicles were sold worldwide. Over the past decade, energy efficiency in passenger vehicles has increased on average by 1.8% per year, a trend which is reflected in all major countries (including North-America, Europe and Japan).

Table 3: Transport sector breakdown

Segment	Technology	Total USD bn
Passenger vehicles	Improved efficiency	14
	Hybrid	5
	Electrical (plug-in hybrid and full electric)	1
	Electric infrastructure	<<1
Freight vehicles	Light duty vehicles and medium trucks	5
	Heavy trucks	2
Aviation and marine	Overall investments	<1
Total		**27**

Source: Ecofys estimates Note: Start stop technology is included in the improved efficiency category and represents USD4bn

Table 3 shows that of the USD27 billion total investment in energy efficiency in transport in 2012, nearly three-quarters were in passenger vehicles. The remaining quarter of investments were made in commercial vehicles.

The most important drivers for energy efficiency in transport are emission standards or fuel economy standards. These standards prescribe how much CO_2 is allowed to be emitted per kilometre of driving, over a standardised driving cycle. In the European Union, US, Japan, China, South Korea, Taiwan and Canada fuel consumption standards are becoming stricter each year. The majority, close to 70%, of all new vehicles sold globally are sold in these countries.

Several measures have been taken to improve the performance of the engine, transmission and the vehicle itself to reduce CO_2 emissions. The lion's share of efficiency investment is related to passenger cars with conventional drivetrains. Our estimates, based on CO_2-emission trends of passenger vehicles in Japan, EU-27, China, South

Korea, Canada and the United States, point to an energy and emissions reduction of 20% over the last decade. The additional costs for this improvement are estimated at about USD300 per vehicle to take investments in improved energy efficiency of passenger vehicles to USD14bn. The IEA estimates that over the last decade, the emission performance of medium trucks and light commercial vehicles has improved by 15%.

Hybrid vehicles are gaining market share in North-America, Japan (the largest market) and Europe. The largest market for hybrid vehicles is Japan with almost a million hybrid cars sold in 2012 according to the International Council on Clean Transportation Europe. In the United States and Europe the market shares are lower having sold respectively about 360,000 and about 125,000. Over the past five years, the European market shows an average growth of almost 30% per year while in the United States a growth of over 40% was seen in 2012. The consumer-price of hybrid cars varies between manufacturers and types and typically starts just little under USD 20,000.

The market for electric vehicles is still small. In 2012, 55,000 plug-in hybrid vehicles and 57,000 full electric vehicles were sold globally, bringing the total sales of electric vehicles to 112,000 in 2012. The total additional investment is just over USD1 billion. According to the IEA, roughly one third of the costs for a full-electric car are determined by the investment in the battery. The battery costs for plug-in hybrid electric vehicles are lower, because of a smaller battery. The consumer-price of both plug-in hybrid vehicles and full electric vehicles start around USD 30,000.

We also look at improvements in energy efficiency in aviation and shipping. The world's maritime fleet comprises more than 100,000 ships with a load capacity of more than 100 billion tonnes. Roughly 50% of these ships are categorised as cargo ships, with cargo ships together representing roughly 90% of the gross tonnage of the maritime fleet. Energy efficiency measures in maritime shipping include propeller and propulsion system upgrades, hull coating and main engine retrofits and retrofit hull improvements. The costs of implementing these measures are dependent on ship size and specific ship characteristics, but overall range from USD50,000 to USD250,000. On these assumptions we estimate that the investments in energy efficiency will not exceed USD500million.

For airplanes, operational fuel costs have always been an important driver of energy efficiency. Consequently, there are few inefficient planes sold each year. A study from the International Air Transport Association (IATA) demonstrates that investments in airplanes focus on engine retrofits and airframe technology and are approximately USD200 million per year. Retrofit measures, like the addition of winglets, only represent moderate levels of investment, and are not thought to be significant at the global level.

We do not include calculations on the energy efficiency gains from modal shift here. While modal shift (i.e. using lower carbon per kilometre forms of transport such as trains instead of cars) is a desired goal to reduce high carbon intensity energy, often the reason for investment is not originated from a desire to reduce energy use.

In the transport sector, the sector is working towards complying with the tighter fuel economy or CO_2 emission standards that are set for various regions for the years 2015, 2020 and 2025. Especially when standards reach the level where a conversion to alternative drivetrains, like hybrid and electric, is needed, investments will rise substantially. Although the initial stimulus for innovation and efficiency has been driven by the expected, or known, level of future standards, this has now led to dynamics where many

manufacturers already overachieve. Next to increasing fuel prices, this will also lead to more efficient cars in countries without standards.

USD 56bn in industry

Energy efficiency in industry can be achieved in many different ways, including in many cases product, or even site-specific (such as optimisation of process or re-use of heat), measures. The number of generic options is limited but includes: efficient motor systems, applying variable speed drives and combined heat and power generation (CHP). According to the World Bank, industry has been decoupling its energy use from value generation. In fact between 2001 and 2011 manufacturing doubled its value added while its energy consumption only increased by 36%. Within the industrial sector energy consumption is made up of 24% electricity, 71% fuels and 5% from heat generated at other sites. About two-thirds of the electricity consumption is used in motors, to drive pumps, fans and compressors.

Table 4: Industry

Sector	Technology	Total USD bn
Industry	Motors	4
	Variable Speed Drives	29
	Heating efficiency	23
Industry Total		**56**
Other	Agriculture, fishery and forestry	8
	Combined Heat and Power	3
Other – total		11

Source: Ecofys

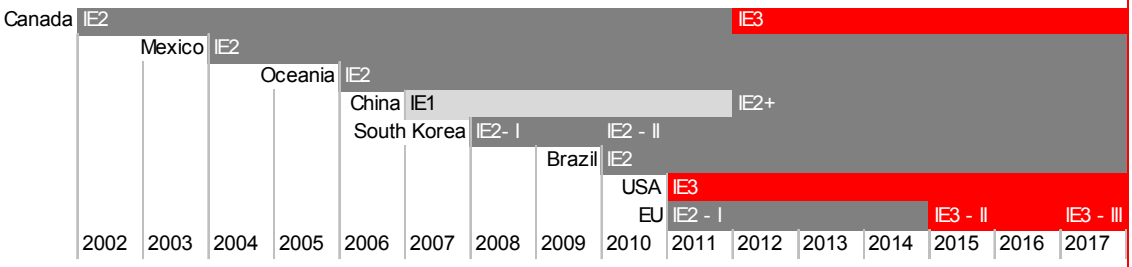
Energy efficiency measures in the manufacturing industry typically relate to site specific optimisation of production processes, re-use of heat and improving energy management. We estimate the investments in this diverse collection of measures based on the average improvements in energy efficiency in recent years, estimated at a rate of 0.8% per year between 2000 and 2010. Based on this improvement rate, we estimate the investments in improving industrial efficiency (of heating processes) to be USD23 billion in 2012, of which USD15 billion is located in China. In the absence of policy, the key drivers of investments in energy efficiency are energy and feedstock costs. Within China's 11th Five Year Plan (2006-2010), the Top1000 programme was rolled out, a mandatory energy savings programme targeting the 1000 largest industrial enterprises in terms of energy consumption. In the sixth Five Year Plan (2011-2015), this programme is expanded to the 15,000 largest industrial energy users.

For industrial motors the entire installed market totalled USD22 billion in 2012, of which energy efficient motors represented UD$16 billion. The efficiency of electric motor systems can be significantly improved by applying variable speed drives and by preventing energy losses in the system the motor is driving. Since systems are very site and process specific, we have only looked at electric motor systems and variable speed drives.

We estimate that total (additional) energy efficiency investments in motors in 2012 totalled USD4 billion. More than 60% of the motor market value came from sales of the IE2 class or higher and China accounted for 22% of the market value.

There are four energy efficiency categories distinguished in motor systems IE1 (standard efficiency) to IE4, where the latter represent the highest efficiency category. Presently, the IE1 category is still dominant in the motor market. However policy is driving market share gains in the higher efficiency categories. Many regions in the world have set minimum standards for motors which are becoming more stringent over time. In Canada the IE3 class is already the minimum standard and the EU will follow by 2015 for larger motors and in 2017 for smaller motors.

Chart 6: Minimum energy performance standards in different regions



Source: IMS

The efficiency of motor use can be further improved by applying variable speed drives (VSDs), or variable frequency drives, replacing inefficient control of output. VSDs control the speed of a motor by changing the frequency of the power input. Next to energy savings this also facilitates a smoother operation of the motors. In 2012 the total investments in VSDs were USD29 billion. Most drives are sold in Asia.

Many regions and countries have introduced, or are introducing and tightening minimum standards for electric motors, such that we expect the market to continue to grow in the coming years. For industrial efficiency in general, the prospects are modest. China will proceed with its mandatory programmes, as will various other countries including the US, India and several European countries. Emission trading systems could become an important driver, but for the time being prices are at levels that will not provide a strong additional incentive (beyond energy prices) to invest in energy efficiency.

The market for CHP has been quite weak in recent years, and could remain so in the coming years. An exception could be the US where the current administration has announced a policy on investments in industrial energy efficiency, including the addition of 40 GW of new CHP capacity by 2020.

Conclusions

We believe our approach is the best available with current data and methodology. However, there is wide uncertainty on the numbers. Our values are higher than estimates from other organisations, as shown in table 5 below. We believe this is partly simply a function of growth in energy efficient investments and partly because we have looked at more regions and technologies than other studies.

Table 5: Comparison of the estimate of global energy efficiency investments with those of other studies.

Study	Estimation (USD bn)
Global Status report on Energy Efficiency, 2007 data	80
IEA World Energy Statistics, for 2011	147 - 300
Roland Berger, for 2011	61
ACEEE, for 2010	90 (USA only)
Climate policy initiative, average for 2006-2010	26 (China only)
Ecofys and HSBC	365 (330 - 410)

Source: Ecofys, 'Clean Economy, Living planet – the race to the top of Global clean energy technology manufacturing 2012, ACEEE is the American Council for energy efficiency economy

In 2008 Ecofys calculated energy efficiency investments in 2007 for the Renewable Energy and Energy Efficiency Partnership (REEEP), in its Global Status Report on Energy Efficiency 2008. Since 2007 there has been growth in new buildings with improved performance, as well as in efficient passenger cars, hybrid cars, efficient lighting and industrial energy efficiency.

The most recent estimate from the International Energy Agency (IEA) is based on information about initiatives by the public sector, multilateral finance institutions and major private institutions.

They note that their investment range is considered conservative, as it likely under-estimates private sector energy efficiency activity.

The Roland Berger study focused only on a limited set of technologies (micro combined heat power, insulation, heat pumps and heating, air-conditioning, CFL and LED lighting, LED lighting, fuel cells). In addition, they may only have counted primary sales of, e.g. insulation material, and have not included trade margins and installation costs, as we have in our analysis.

We believe our analysis demonstrates that investment in energy efficient goods and services is thriving. In fact, in 2012 it was greater than investment in renewable energy technologies. REN 21, the renewable energy policy network for the 21st Century estimates that investment in renewables was USD244bn in 2012.

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What next?

- Energy efficiency accelerates decarbonisation in the short run, meets energy security goals and provides health benefits
- Clarity around the definition of energy efficiency has been a hurdle to unlocking investment flows, this is changing
- Now green bonds are providing transparency on projects and offer scale up potential

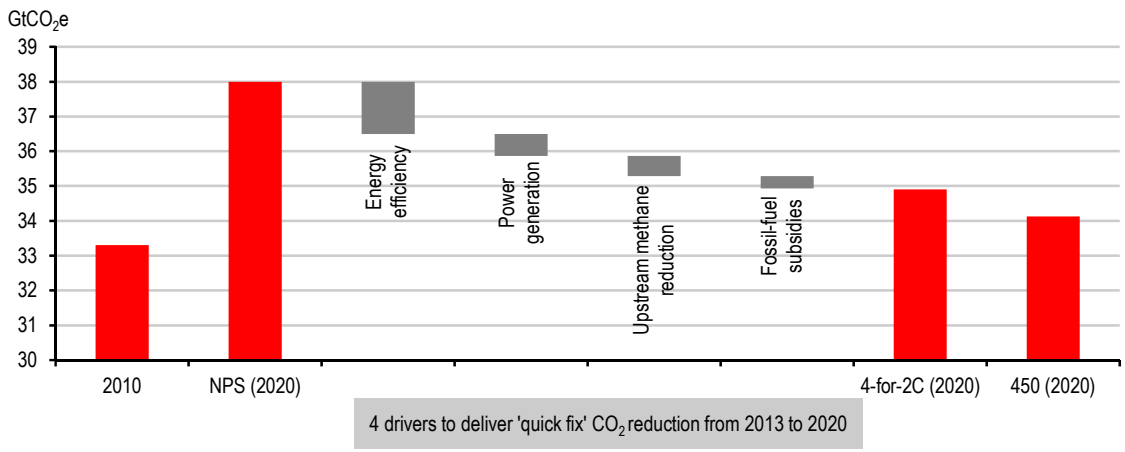
Short-term CO_2 gains

The 2015 international climate negotiation in Paris (CoP21) will set the tone for post-2020 emission goals, but in the meantime pre-2020 carbon ambition hinges on energy efficiency.

In June 2013, the IEA special report "Redrawing the Energy Climate Map" set out four solutions for a "quick fix" to put the global energy framework back on track for a 2°C world (Chart 7). Energy efficiency is at the top of the list, with the potential to contribute 1.5GtCO_2 in emission reductions from 2013 to 2020, or 49% of the total reduction targets.

In our November 2013 report, '*The cold calculus of cash and carbon*', we argued that energy efficiency could be the largest contributor to global GHG reduction by 2020 by introducing energy performance standards for new heating and cooling equipment, lighting and appliance in buildings; more efficient industrial motors; and tighter fuel economy standards for transport.

Chart 7: Change in world energy related CO2 and CH4 emissions to stay on track for a 2°C world*



Source: Redrawing the Energy –Climate Map, IEA. *Note: New Policy Scenario (NPS) assumes cautious implementation of current climate pledges and energy policies, 450 (2020) reflects emission levels associated with a 50% chance of keeping temperature rises below 2°C, the global policy goal.

Many countries are already well versed in terms of improving energy efficiency: China has the theme embedded into the 12th Five Year Plan, implying that the energy saving and environmental market could be worth 6% of GDP by 2015 (See *'2014: the year of reconnect'*, January 2014). In the EU, the new Energy Efficiency Directive entered into force in December 2012 and should yield 17% energy savings by 2020. (See *'EU: doing the climate foxtrot'*, February 2014). In Germany, we believe that energy efficiency will play the key role in delivering the aspirations of the Energiewende in terms of reducing energy demand by 20% by 2020 (Chart 8).

However, despite these positive developments, 2013 has been a relatively slow year for new climate policies (Chart 9). 30 new energy efficiency policies were added in 2013, a modest decline from 34 in 2012. 2014 will be a bumper election year with general elections in Brazil, India and South Africa, mid-term congressional pools in the US as well as elections for the European Parliament, which could put climate ambitions on the back burner for the time being. For instance the US mid-term elections were a key reason for delaying the submissions of draft country pledges to 2015 for the global deal. However, we expect policies to pick up in 2015 to be aligned with delivering a global agreement in Paris 2015 – the central ethos from the UN Convention on Climate Change on this is that national legislation should be the basis for country pledges.

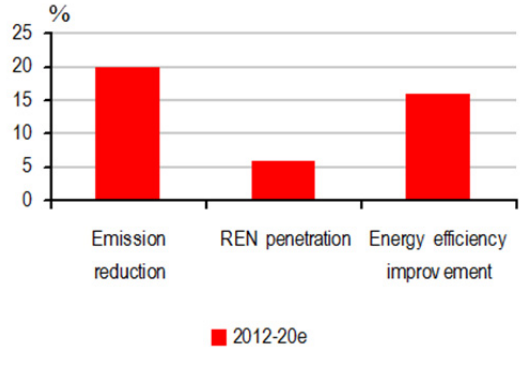
Scaling up financing

Asset owners are relatively comfortable with renewable energy as a portfolio theme, particularly within infrastructure allocations. In contrast, efforts to improve exposure to energy efficiency themes within portfolio holdings are generally less developed, with the exception of direct real estate investments and collaborative initiatives such as the CDP's Carbon Action programme, which has helped to stimulate energy efficiency measures with an average payback of three years. Scaling up these efforts across all assets is the quickest and cheapest way of postponing lock-in to a high carbon pathway (See *'Shifting Capital Markets by 2°C'*, 7 March 2013).

More focus on health

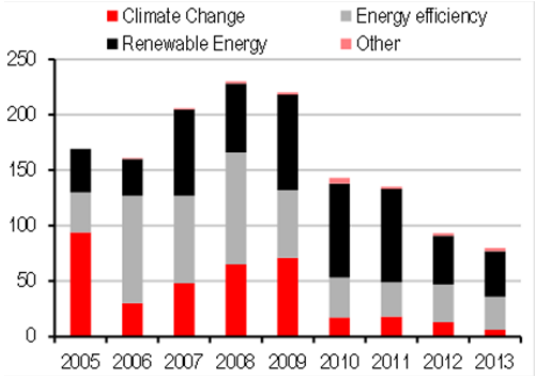
A potential boost to energy efficiency investment is the launch of a major study by the World Green Building Council (World GBC) on the health and productivity benefits associated with green buildings. Previous studies have shown that simple measures such as improved ventilation can increase productivity by up to 11%, while improved lighting design in an office can increase productivity by up to 23%. Establishing the link between green building technologies and employee productivity helps to provide more transparency on the business case for investments in energy efficiency.

Chart 8: Energiewende targets



Source: ag-energiebilanzen,

Chart 9: Annual total number of climate policies



Source: IEA Policies and Measures Database, Globe Climate Legislation Study 2014.
Note: Other includes forestry (LULUCF and REDD+), waste and adaptation policies

Enter green bonds

In the past few years there has been growing activity to mobilise bonds to finance the low-carbon, green economy. We estimate that the broad issuance of bonds aligned with the climate economy grew to USD74bn in 2012, an increase of 25% from the 2011 level (Chart 10). Overall, the total value of climate aligned bonds outstanding was USD346bn (see *Bonds and climate change: the state of the market*, 7 June 2013). However, climate alignment is broader than green, since an activity that reduces carbon emissions may not be considered green to many environmentalists (nuclear power for instance).

Meanwhile, we also see a small but fast growing volume of specifically badged green bonds where the use of proceeds is explicitly allocated to purposes such as renewable energy and energy efficiency. In addition new initiatives such as the 'Green Bond Principles' (please see '*The HSBC Guide to Green Bonds*', 27 January 2014), are also driving the market.

Of the USD11bn of green issuance in 2013, we estimate that cUSD9bn could have been (according to the investment mandate) allocated to energy efficiency.

So far, the green bond market is dominated by the Supra-nationals, agencies and multilateral development banks, and we include a selection of projects their proceeds have been allocated to below. The top issuers are shown in chart 11 below.

Kommunalbanken (KBN) of Norway has been innovative in green financing and so far has USD1.4bn (NOK8.4bn) of loans outstanding for a green portfolio. KBN raised USD878m to be invested in the construction of new passive house buildings in the Overhalla nursery school in Norway. The total building cost of NOK25m (USD4.1m) is financed by KBN's green bond portfolio, at a 'green' interest rate. According to KBN, the green lending rate is lower than the market average.

The European Investment Bank is a leader in climate aligned and green finance and has so far raised cUSD5bn in the green bond market. In 2009, through the Climate Awareness Bond programme, the EIB provided EUR145m financing to develop district heating in east Paris, building a 9km pipeline serving three districts and their immediate suburbs.

Within the transport sector the EIB also provided EUR30m financing to AVL List GMBH, an engineering company in Austria in 2011. Another investment in EIB's Climate Awareness Bond portfolio, the financing will be used by AVL List GMBH to carry out R&D in powertrain engineering, including the development of hybrid technology and batteries for electric trains.

The World Bank is another significant issuer in the green bond market, having raised USD4.5bn since the inaugural green bond issue in 2008. In 2009, the World Bank provided USD125m financing from its green bond portfolio to improve energy efficiency in heat and power generation in selected towns in Belarus. Existing heat-only-boiler plants are being converted into combined heat and power plants which are more energy efficient. The project is expected to reduce CO2 emissions by 165,200 tons/year upon completion, according to estimates from the World Bank's environmental specialists.

Similarly, the EBRD has issued a series of Environmental Sustainability Bonds totalling USD400m. The proceeds from these bonds form part of EBRD's Green Project Portfolio, which has made 261 loans totally EUR4.7bn as of the end of June 2013[1], in areas including energy efficiency and clean energy. In 2012, the EBRD extended a EUR35m loan to Metsä Tissue Oyj to replace its existing paper machines in Poland and Russia with more energy-efficient ones. The

1 see EBRD website, data retrieved 27 Feb 2014.

energy consumption of the new equipment will be lower than the European Union Best Available Techniques (BAT) and CO2 emissions is expected to be reduced by 35,000 tons/year.

Conclusions

The regulatory drivers, namely carbon constraints, energy security, health benefits and industrial competitiveness issues, are in place to be supportive of further growth in energy efficiency segments. We expect increasing financing specifically aligned to energy efficiency to be provided through the bond market. There are however equity opportunities, which we discuss in our sister publication '*Investing in energy efficiency*', 27 March 2014.

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Disclosure appendix

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The following analyst(s), economist(s), and/or strategist(s) who is(are) primarily responsible for this report, certifies(y) that the opinion(s) on the subject security(ies) or issuer(s) and/or any other views or forecasts expressed herein accurately reflect their personal view(s) and that no part of their compensation was, is or will be directly or indirectly related to the specific recommendation(s) or views contained in this research report: Zoe Knight, Charanjit Singh and Wai-shin Chan

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1 This report is dated as at 27 March 2014.
2 All market data included in this report are dated as at close 24 March 2014, unless otherwise indicated in the report.
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