

Global energy efficiency primer - less is more



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Energy efficiency - a global thematic megatrend

As part of our work on megatrends, we update our 2012 report on energy efficiency with a Primer and [Primer Picks](#) report. We believe the world is facing a global energy crisis, with primary energy demand accounting for 7-9% of GDP and demand expected to grow by at least one-third by 2035. As a result, energy-related CO2 emissions are likely to increase by 20%, following a trajectory consistent with a long-term average global temperature increase of up to 4.0°C – making irreversible climate change a reality, according to the IEA and World Bank.

Energy efficiency is the answer

In a resource-constrained world, energy demand needs to adjust to limited supply. The rationale for change includes: economic development and competitiveness, rising energy costs, and protecting the environment. We believe that energy efficiency – reducing the amount of energy required to provide products and services – is the logical response. We also believe that the recession is making “less is more” the maxim of our era, and that energy independence and security are contingent on energy efficiency.

Greatest potential for energy, cost and emissions savings

End-use energy efficiency offers the greatest potential to lower both energy demand and CO2 emissions. It offers considerable low-hanging fruit given that two-thirds of the economic potential to improve energy efficiency remains untapped (source: IEA). Cost will be the key driver, in our view, with a general rule of thumb across sectors that every dollar spent on energy efficiency means US\$2-4 in lifetime cost savings – and paybacks averaging 3-7 years.

Seven major entry points for investors

We have mapped energy efficiency exposure across a number of sectors' value chains to highlight the diverse range of entry points available to those wishing to invest in the energy efficiency theme: (1) Automobiles; (2) Buildings; (3) Industrials and Integrated Plays; (4) IT; (5) Lighting and LEDs; (6) Smart Grid and Energy Storage; and (7) Transport – Bus, Rail, Shipping and Lightweighting. We examine these areas more fully in standalone sections of the report.

BofAML Energy Efficiency Stock list & Primer Picks

Together with our sector analysts, we have created a list of 113 global stocks covered by BofAML – including 30 new names – that have exposure to energy efficiency-related products, services, technologies, themes and solutions. We examine their exposure to the theme and their long-term growth prospects. Our Buy-rated stocks with material exposure to the theme are detailed in an accompanying [Primer Picks](#) document, as is our full stock list.

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Refer to important disclosures on page 193 to 196. Link to Definitions on page 192.

[See further - Global Energy Efficiency Primer Picks & Stock List](#)

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**Cross Reference - Global Energy
Efficiency Primer Picks**

Thematic Investing, 18 April 2013

Less is more Investing in global energy efficiency

We are facing a global energy crisis with primary energy demand expected to rise by a third between 2010 and 2035. As a result, energy-related CO2 emissions are likely to increase by 20%, following a trajectory consistent with a long-term rise in the average global temperature in excess of 3.5°C, according to the IEA and World Bank. In a resource-constrained world, energy demand inevitably has to adjust to limited supply. We see the rationale for change as follows:

- energy supply-demand balance;
- costs and economic competitiveness;
- energy security;
- environmental sustainability;
- access to energy and fuel poverty.

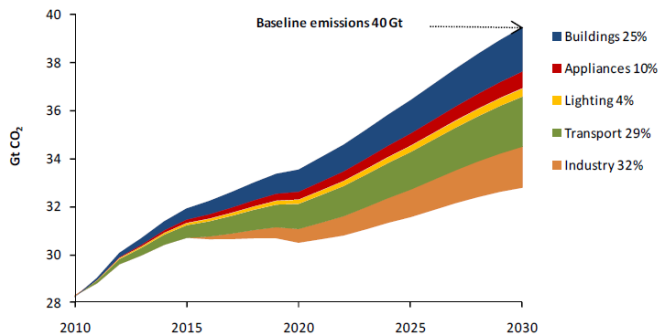
We believe energy efficiency – a reduction in the amount of energy used to provide products and services – offers the fastest, cheapest and most efficient way to cut energy costs, CO2 emissions, and long-term energy demand.

We have mapped energy efficiency exposure across a number of sector value chains to show the range of entry points available to those wishing to invest in the energy efficiency theme: (1) Autos; (2) Buildings; (3) Industrials & Integrated; (4) IT; (5) Lighting & LEDs; (6) Smart Grid & Energy Storage; and (7) Transport – Bus, Rail, Shipping & Lightweighting. We examine these more fully below.

BofAML Global Energy Efficiency Stock list is not a recommended list either individually or as a group of stocks. Investors should consider the fundamentals of the companies and their own individual circumstances/objectives before making any investment decisions

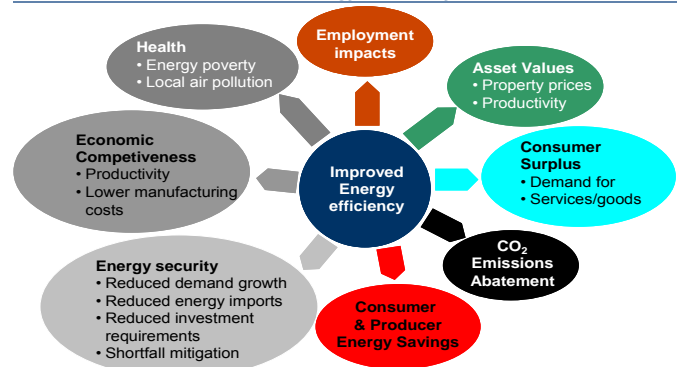
BofAML Global Energy Efficiency Exposure Stock list: Based on our view of the level and materiality of exposure to energy efficiency themes – and the role of energy efficiency as a long-term growth driver – we have created a list of stocks covered by BofAML. The aim of the stock list is to provide investors with the information to identify company and sub-sector specific risks and opportunities inherent in the energy efficiency theme.

Chart 1: Potential CO2 emissions savings via energy efficiency



Source: IEA's Clean Energy progress Report 2011

Chart 2: Benefits of improved energy efficiency



Source: IEA, BofA Merrill Lynch Global Research

BofAML Global Energy Efficiency Stock list

BofAML Global Energy Stock list is not a recommended list either individually or as a group of stocks. Investors should consider the fundamentals of the companies and of their own individual circumstances / objectives before making any investment decisions.

We have mapped energy efficiency opportunities across seven major themes: 1) Automobiles; 2) Buildings; 3) Industrials and Integrated Plays; 4) IT; 5) Lighting and LEDs; 6) Smart grid and Energy Storage; and 7) Transport – Bus, Rail and Shipping. We outline these areas below and examine them in much greater detail in standalone sections in the report.

For each theme, together with our BofAML Global Research sector analysts we have estimated the level and materiality of companies' exposure to energy efficiency themes – and the role of energy efficiency as a long-term growth driver. For each company, we have characterised their energy efficiency exposure according to the following scale and criteria:

- **Low** – Energy efficient products, services, and services are not very material to global revenues and/or growth but are a factor among others for the business model, strategy & R&D of the company.
- **Medium** – Energy efficient products, services, and services are an important factor for the business model, strategy & R&D of the company; material to sales and/or growth.
- **High** – Energy efficient products, services, and services are core to the business model, strategy and R&D of the company; material sales and/or growth driver; pure play (ie, 100% of sales from equipments, products, services or solutions which reduce energy use and CO2 emissions).

Although it is difficult to accurately gauge the link between such exposure and share price performance (as many factors outside the scope of this analysis are likely to play a role in short- and long-term price development), we still consider energy efficiency exposure as an important positive point to track.

The aim of the Global Energy Efficiency Exposure Stock List and its seven underlying themes is to provide investors with information to identify company and sub-sector specific risks and opportunities that are inherent in the energy efficiency theme.

Table 1: BofAML Auto & Energy Efficiency Stock List

Company	EE exposure
BORGWARNER INC	High
FLEETMATIC	High
INFINEON	High
LINEAR TECHNOLOGY	High
MAHLE METAL LEVE	High
SANKEN ELECTRIC	High
SENSATA	High
TESLA MOTORS INC	High
VALEO SA	High
MAHLE METAL LEVE	High
SENSATA	High
VICTREX	High
AUTOMETAL	Medium
CONTINENTAL AG	Medium
DELPHI ATOMOTIVE	Medium
HONEYWELL	Medium
JOHNSON CONTROLS INC	Medium
JOHNSON MATTHEY PLC	Medium
MAGNA INTERNATIONAL	Medium
MICHELIN (CGDE)-B	Medium
TENNECO INC	Medium
AQUARIUS PLATINUM	Low
LANXESS	Low
LKQ CORP	Low
SOLVAY	Low
TORAY INDUSTRIES INC	Low

Source: BofA Merrill Lynch Global Research. * EE exposure = BofAML estimates of energy efficiency exposure.

Cross Reference - Global Automotive Supplier Review's "The Path Towards Fuel Efficiency"

A comprehensive overview of the efficiency and fuel economy issues raised in the Auto section can be found in our Global Auto team's "Who Makes the Car" report

[Global Automotive Supplier Review, 17 April 2013](#)

Auto, green "transficiency" evolution

Globally, road transport-related CO2 emissions represented almost 17% of the total CO2 emissions from fuel combustion in 2009 according to the IEA.

Road transport was thus the third highest source of CO2 emissions from fuel combustion. Within road transport, automobiles and light trucks produce well over 60% of emissions (source: IEA). With non-OECD and emerging market car sales set to exceed those in the OECD by 2020, and the global passenger car fleet set to double to reach almost 1.7bn by 2035, the auto sector is coming under growing pressure on oil consumption, energy security and CO2 emissions. With limited near-term scope for oil substitution in transport – and a robust increase in oil demand expected for the next five years – we think the sector will need to make significant gains on fuel economy via efficiency gains and upgrading the fleet.

We believe that ultimate path towards automotive fuel efficiency will be more of an evolution than a revolution. It could involve a three stage transition including: (1) leveraging technology to improve the efficiency of the internal combustion engine and light weighting of the vehicle; (2) increasing use of hybrid and hybrid electric powertrains; and (3) exogenous technology shock. Growing fuel efficiency and CO2 regulations around the world are placing an increasingly significant R&D burden on all auto OEMs, but we do not believe that regulation alone will be a driver of material changes. We anticipate the evolution will be market driven as consumers demand more fuel efficient vehicles to ultimately reduce personal expenditure on fuel.

We believe that a number of stocks are well placed to benefit from the theme of energy and fuel efficiency in the auto sector through their involvement in areas such as autocatalysts, diesel, electric vehicles (EVs), engine and transmission components, gasoline direct injection (GDI), light-weighting, li-ion batteries, natural gas, specialty polymers, turbochargers, tyres and fleet management, among other areas.

Table 2: BofAML Buildings & Energy Efficiency Stock List

Company	EE exposure
INGERSOLL RAND	High
ITRON	High
KONE	High
LEGRAND	High
MELROSE	High
OWENS CORNING	High
SAINT-GOBAIN	High
CSR LIMITED	Medium
ELECTROLUX	Medium
GENERAC	Medium
HOME DEPOT	Medium
JOHNSON CONTROLS	Medium
HONEYWELL INTL.	Medium
LOWE'S COMPANIES INC	Medium
PHILIPS	Medium
NIPPON SHEET GLASS	Medium
SCHNEIDER	Medium
UNITED TECHNOLOGIES	Medium
REXEL	Low
WHIRLPOOL	Low

Source: BofA Merrill Lynch Global Research. * EE exposure = BofAML estimates of current sales derived from energy efficiency products, services, technologies and solutions.

Buildings - the easiest & largest efficiency gains

Energy consumption within buildings is the single largest component of global energy use and CO2 emissions, at c.40% and c.30%, respectively. The biggest culprits are heating and cooling, which, together with lighting, can account for up to 60% of a building's energy consumption. We believe that improved energy efficiency in the buildings sector offers the greatest potential of any sector to make cost savings and reduce energy use – by 30% to 50% by 2030-50, respectively, according to the IEA. Moreover, little of this has been captured – with 80% of the economic potential of energy efficiency in buildings remaining untapped, largely due to challenging non-technical barriers (source: IEA).

In addition to a housing sector rebound, the biggest driver for improving energy efficiency in buildings is reduced energy use and therefore costs; it also lowers the capex needed in energy infrastructure, and promotes energy security. The average payback for efficient building technologies is only three years in terms of electricity and 9-14 years for fuels (source: IEA). Long-term growth drivers are extremely favourable, in our view, and include: high energy and electricity prices, stricter regulations and building codes, ageing stock, increasing renovation/DIY, EM urbanisation and growth, favourable demographics, efforts to lower CO2 emissions, affordable housing, tackling fuel poverty, realising a green premium on green buildings, the low-risk nature of financing efficiency, and the economic importance of the sector in terms of GDP and jobs.

The global market for energy-efficient building technologies is expected to increase from US\$68bn in 2011 to US\$103.5bn in 2017 – a CAGR of 7.25% (source: Pike Research). The “green” or energy-efficient building market in the US alone has grown from US\$10bn in 2005 to US\$85bn in 2012, and is expected to reach US\$98-106bn in 2013 and US\$204-248bn by 2016 (source: McGraw-Hill Construction)

We believe a number of stocks are well placed to benefit from the theme of energy efficiency in buildings, including those with exposure to: building automation, energy services (ESCOs), efficient HVAC systems, insulation materials and technologies, high-efficiency lighting (including LEDs) and appliances, windows (including multiple glazing and low-e), and the distribution of building products.

Table 3: BofAML Industrials and Integrated Plays & Energy Efficiency Stock List

Company	EE exposure
DELTA ELECTRONICS	High
GEA	High
HEXCEL CORP	High
LEGRAND	High
SMC CORP	High
SPECTRIS PLC	High
SPIRAX-SARCO	High
ALFA LAVAL	Medium
ALSTOM	Medium
CORNING INC	Medium
DAIKIN INDUSTRIES	Medium
ELECTROLUX AB-SER B	Medium
HONEYWELL	Medium
NEXANS	Medium
PHILIPS ELECTRONICS	Medium
ROCKWELL	Medium
SCHNEIDER	Medium
SIEMENS AG	Medium
ATLAS COPCO	Low
CROMPTON GREAVES	Low
EATON CORP	Low
HEXAGON AB	Low
INVENSYS PLC	Low
METSO OYJ	Low
PRYSMIAN	Low
REXEL SA	Low
SIEMENS LTD	Low
SKF AB	Low
VALLOUREC	Low

Source: BofA Merrill Lynch Global Research. * EE exposure = BofAML estimates of current sales derived from energy efficiency products, services, technologies and solutions

Industrials & integrated plays, the enablers

Industry accounts for 28% of global energy consumption and 32% of CO2 emissions (source: IEA). The long-term case for energy efficiency is clear – with 80% of energy lost across the value chain from inefficiencies between the gathering of energy sources and their eventual consumption in industry (source: ABB). The IEA estimates that industry could improve its energy efficiency by almost a third and reduce CO2 emissions by up to 32% via the adoption of currently available best practices and technologies. Moreover, the cost savings are significant – with paybacks for industry, an estimated three years in OECD countries and five years in non-OECD countries (source: IEA).

Industrial and integrated plays – and the Cap Goods sector in particular – are key enablers for improving the energy efficiency of equipment and power, and thus industrial productivity. We expect efficiency to be a long-term growth driver for the sector on the back of megatrends such as: rising energy prices, EM growth in power and automation, expanding production volumes, grid and generation build out, renewable interconnections, and CO2 and environmental regulations.

While energy efficiency should drive product replacement cycles, we assume that the Capital Goods sector currently faces lower growth prospect than between 2004 and 2011. Among the strongest growth outliers are structural opportunities (shale gas, resource scarcity, food/beverage and pharma capex, LNG, transmission, aerospace), the aftermarket and recovery plays (US housing, commercial construction, lighting/LEDs appliances and power). The weakest are those impacted by austerity (government-related spending) and a tougher competitive environment (power, construction equipment, appliance, railway equipment), and GDP plays (European trucks and industrial production).

We believe that a number of stocks are well placed to benefit from the theme of energy efficiency for industrials and integrated plays through their involvement in areas such as automation (building and industrial), controls, grid and smart grid, heat transfer, lighting, power distribution and generation, process management, renewable interconnections, and T&D, among others.

Table 4: BofAML IT & Energy Efficiency Stock List

Company	EE exposure
ANALOG DEVICES	High
ARM HOLDINGS	High
ASML	High
EMC CORPORATION	High
FLEETMatics GROUP	High
EQUINIX INC	High
IBM	High
INFINEON TECH.	High
INTEL	High
INTERXION	High
LINEAR TECHNOLOGY	High
MAXIM INTEGRATED	High
SALESFORCE.COM	High
SANKEN ELECTRIC CO	High
SPLUNK	High
STMICROELECTRICS	High
TERADATA	High
TIBCO SOFTWARE	High
TOSHIBA CORP	High
AMAZON	Medium
APPLE	Medium
CISCO SYSTEMS	Medium
VMWARE	High
GOOGLE	Low
HEWLETT-PACKARD CO	Low

Source: BofA Merrill Lynch Global Research. * EE exposure = BofAML estimates of current sales derived from energy efficiency products, services, technologies and solutions

IT, “big data” & semis

The global boom in “big data” on the back of explosive growth in unstructured traffic (aka big data) driven by smartphones (1bn by 2015), internet users (50% of global population by 2016), and mobile traffic growth (13x growth expected in the next five years) is seeing the global IT sector emerge as a new target area in terms of energy efficiency. Data volumes are projected to grow up to 50x to 2020E (source: IDC). This means a significant increase in electricity consumption, with the sector consuming 1.5% of the world’s energy (source: Pike Research) and upwards of 3-5%+ of electricity in markets such as the EU, the US and Japan (source: ACEEE). Between 2011 and 2012, power requirements grew by 63% globally to 38GW (source: Datacenter Dynamics). Its global CO2 emissions – c.2% of the world’s total – are already on a par with the aviation sector.

Growing energy consumption and prices mean that energy costs are leading to business and capacity constraints, particularly for energy-hungry data centres. The combination of rigid, hierarchical structures in networking and storage domains in data centres and the fact that data centres are scaling up to massive sizes (10x growth) means there is an increasing need to lower power costs. Investment in data centres grew globally by 22% to US\$105bn in 2012 (vs. US\$86bn in 2011) and investment is projected to increase by a further 14.5% in 2013 (source: Datacenter Dynamics). **We expect this to create significant opportunities for the ‘greening’ of data centres**, with the market having grown from US\$7.5bn in 2010 to US\$17.1bn in 2012. By 2016E, the market is expected to reach US\$45.4-69.7bn (source: Pike Research, Wintergreen Research). We believe that this should benefit two larger IT trends – virtualisation and cloud computing, both of which help to improve data centre energy efficiency.

We also expect energy efficiency to become a major growth driver for the US\$117bn addressable cloud computing market, as well as virtualisation, as they can help to lower energy use and emissions by 30-90%.

We regard semiconductors as a key enabler of realising energy efficiency in the automobiles, buildings, IT, capital goods, and transport sectors – as well as aiding the business case for renewables. We believe the c.US\$300bn sector is returning to robust growth on the back of a combination of increasing demand from a gradual economic recovery, improving confidence in distribution/retail to carry more inventory, pricing recovery in sectors such as memory, and secular tailwinds from product cycles.

We believe that a number of stocks provide exposure to the theme of energy efficiency in IT through their involvement in areas such as cloud computing, consolidation, data centre design and operation, DCIM, heating and cooling, power management, thin provisioning, virtualisation, and semiconductors.

Table 5: BofAML Lighting & LEDs Energy Efficiency Stock List

Company	EE exposure
CREE INC	High
EPISTAR	High
EVERLIGHT	High
SEMILEDS CORP	High
SEOUL SEMICONDUCTOR	High
VEECO INSTRUMENTS	High
PHILIPS ELECTRONICS	Medium
SIEMENS	Medium
GENERAL ELECTRIC	Low

Source: BofA Merrill Lynch Global Research. * EE exposure = BofAML estimates of current sales derived from energy efficiency products, services, technologies and solutions

Table 6: BofAML Smart Grid & Energy Storage Stock List

Company	EE exposure
ITRON	High
MELROSE PLC	High
TOSHIBA CORP	High
ABB LTD	Medium
ALSTOM SA	Medium
CISCO	Medium
EATON PLC	Medium
JOHNSON CONTROLS	Medium
SCHNEIDER	Medium
GE	Low
SIEMENS	Low
SQM	Low

Source: BofA Merrill Lynch Global Research. * EE exposure = BofAML estimates of current sales derived from energy efficiency products, services, technologies and solutions

Lighting & LEDs

Lighting consumes 19% of the world's electricity output and is extremely wasteful with up to 30% to 75% of lighting systems considered inefficient (source: IEA). Without efficiency breakthroughs, it is estimated that electricity consumption by lighting will increase by 60% in the next 20 years (source: UNEP). New technologies can reduce electricity consumption by up to two-thirds. Moreover, energy efficiency lighting sources such as CFLs, LEDs, luminaries, control gear and intelligent lighting control tools and concepts can thus make significant contributions to reducing electricity use and cutting CO2 emissions.

We anticipate strong growth for energy efficient lighting solutions, helping the global lighting market to grow at 5-7% CAGR to become a €75-89bn market by 2015 (source: Philips). While a lacklustre macro economy has impacted the general lighting market in the near term, LEDs in lighting are finally emerging as the biggest growth opportunity in the medium to long term. Short-term LED usage will be driven by mobile phones, TVs and PCS, with 60-70% of new TVs having LED backlighting. While oversupply and low utilisation remain issues, albeit easing, we see the industry pulling into a healthier supply/demand balance past 2014. A speedier drop in LED lighting prices – including the 2013 magic price point breakthrough of Cree's sub-US\$10 LED bulb for Home Depot – could be a major breakthrough for residential solutions. Spurred on by regulation, LEDs could represent 45% of the global lighting market by 2015 (source: Phillips) and residential LEDs could represent 70% of the general light market by 2020 (source: McKinsey).

We believe that a number of companies are well placed to benefit from the theme of energy efficiency in LEDs and lighting through their involvement in areas such as chips, CFLs, CCFLs, components, deposition equipment, LEDs, lighting management, lighting solutions, luminaries, MOCVD equipment, process equipment, and sapphire ingot/wafer manufacturers among others.

Smart grid & energy storage, the ElectriNet

The smart grid represents the main segment of growth in the grid management industry for the next decade, in our view. It is growing at an 11% CAGR from 2012-16E (source: Alstom) and our Alternative Energy team estimates it could represent a global market of up US\$63bn by 2020. Key market drivers include improving grid reliability and stability, increasing distributed generation, renewable energy integration (intermittency), reducing consumption peaks, increasing energy efficiency, EV integration, a greater focus on cyber security, and reducing CO2 emissions. The smart grid should also facilitate and improve prospects for greater energy efficiency in buildings, IT, power generation and T&D, and transport.

AMI – “internetization” of utility services. An important element of the smart grid is advanced metering infrastructure (AMI), including the rollout of smart electric, gas and water meters. Of the combined 2.7 billion electric, gas, and water meters worldwide, less than 15% are automated. While North America is expected to remain a leader, achieving 50% smart electric meter penetration this year opportunities in EMs – particularly in Asia – provide the greatest long-term upside, in our view. Based on announced projects alone, we expect more than 200 million meters to be installed in traditional markets by 2018 with the global smart meter market reaching US\$15bn.

An overview of the smart grid issues raised in this section can be found in Andrew Hughes' Alternative Energy research

Table 7: BofAML Transport – Rail, Bus & Shipping & Lightweighting Stock List

Company	EE exposure
BOMBARDIER INC	High
CANADIAN NATIONAL RA.	High
CHINA RAILWAY GROUP	High
CSR CORPORATION	High
CSX CORPORATION	High
FIRSTGROUP PLC	High
GO-AHEAD GROUP PLC	High
GUANGSHEN RAILWAY	High
HEXCEL	High
NATIONAL EXPRESS GR.	High
NORFOLK SOUTHERN	High
STAGECOACH GROUP	High
UNION PACIFIC CORP	High
VOSSLOH	High
ZHUZHOU CSR	High
ALSTOM SA	Medium
CHINA RAILWAY CONSTR.	High
YANGZIJIANG SHIP.	Low
BOMBARDIER INC	High
CANADIAN NATIONAL RA.	High
CHINA RAILWAY GROUP	High
CSR CORPORATION	High
FIRSTGROUP PLC	High
GO-AHEAD GROUP PLC	High
TORAY INDS.	Low

Source: BofA Merrill Lynch Global Research. * EE exposure = BofAML estimates of current sales derived from energy efficiency products, services, technologies and solutions

Longer term, we believe that grid storage could be a technological breakthrough that could change how energy is produced, consumed and valued. Electricity storage is the ultimate goal of cleantech because it enables: (1) the electrification of transport, (2) the smoothing of renewable intermittency, and (3) the elimination of spatial and temporal price disparities. High cost remains an inhibitor to adoption near term, with utilities considering grid storage in demonstration projects, but we believe investors should become familiar with grid storage technologies and vendors.

We believe that a number of stocks are well placed to benefit from the theme of energy efficiency via smart grid and energy storage from their involvement in areas such as AMI, automatic meter reading (AMR), batteries for grid storage, control rooms, customer-side systems, distributed grid management, electric vehicle (EV) charging infrastructure, ICT integration, li-ion batteries, network management systems, smart power electronics, renewables integration, substation automation, and wide-area monitoring and control.

Transport - rail, bus, shipping & lightweighting

The transport sector accounts for more than 50% of world consumption of liquid fuels, and this share is forecast to increase to over 60% by 2035

(source: International Union of Railways). It also accounts for 23% of global emissions – ie, 6.5bn tonnes of CO₂ – or the equivalent of 1t of CO₂ per inhabitant of the planet. The carbon footprint of transport is linked to the fact that almost 20% of the world's total delivered energy is used in the sector, where liquid fuels are the dominant source (ie, gasoline, diesel and LPG on roads, kerosene in the air, and fuel oil for shipping). With oil substitution not a reality in the near term, this means growing pressure in terms of fuel costs and energy efficiency.

The long-term environment for rail, bus and coach, shipping – and lightweighting for air and road transport – is the most positive it has been in years. High fuel and labour prices, energy security concerns, rising household bills, urbanisation, congestion, environmental concerns and deregulation are all leading to greater investments and utilisation of rail and bus in particular. They are seen as solution providers, transporting more people further and faster, with lower emissions and congestion impacts. While changing mobility behaviour will be key to realising the efficiency opportunity, rail is set for strong growth, including via the switch from truck to rail in the US. The accessible rail market is set to register a 2.7% to 2.8% CAGR to reach €124bn by 2015-16E (source: Bombardier, UNIFE). MENA and Latin America are seeing the fastest growth (source: UNIFE). Bus and coach is also growing at a compound annual rate of 5-6.2% and should become a US\$61.5bn market by 2016E (source: Fredonia). Finally, new environmental regulations from the IMO should see efficiency emerge as a major opportunity in the shipping sector.

We believe that a number of stocks are well placed to benefit from the theme of energy efficiency in rail, bus and shipping via their involvement in areas such as lightweighting, locomotives, passenger rail operators, rail services, railway signalling and control systems, rail transport for freight, public bus and coach operators, rolling stock and fuel efficient shipbuilders.

The BofAML Global Energy Exposure Stock list is not a recommended list either individually or as a group of stocks. Investors should consider the fundamentals of the companies and of their own individual circumstances / objectives before making any investment decisions.

BofAML Global Energy Efficiency Stock List

We have created a BofA Merrill Lynch Global Research list of stocks which have exposure to energy efficiency-related themes and that we consider should benefit from long-term global energy efficiency growth.

The aim of the stock list is to provide investors with information to understand company and sub-sector specific risks and opportunities inherent in the energy efficiency theme. We have also provided factual overviews of other companies, outside of our research coverage, that are exposed to energy efficiency (see relevant sections of the report).

Table 8: Global Energy Efficiency Exposure Stock list

Ticker	Name	Country	BofAML Ticker	EE sub-sector	EE exposure
Auto					
BWA US	BORGWARNER	United States	BWA	Auto	High
FLT US	FLEETMATIC	Ireland	FLT	Auto	High
LEVE3 BZ	MAHLE METAL LEVE	Brazil	MLEVF	Auto	High
ST US	SENSATA	Netherlands	ST	Auto	High
TSLA US	TESLA	United States	TSLA	Auto	High
FR FP	VALEO	France	VLEEF	Auto	High
AUTM3 BZ	AUTOMETAL	Brazil	XAUTF	Auto	Medium
CON GR	CONTINENTAL AG	Germany	CTTAF	Auto	Medium
DLPH US	DELPHI	United Kingdom	DLPH	Auto	Medium
HON US	HONEYWELL	United States	HON	Auto	Medium
JCI US	JOHNSON CONTROLS	United States	JCI	Auto	Medium
MGA US	MAGNA INTL	Canada	MGA	Auto	Medium
ML FP	MICHELIN	France	MGDDF	Auto	Medium
TEN US	TENNECO	United States	TEN	Auto	Medium
GLW US	CORNING	United States	GLW	Auto	Medium
AQP LN	AQUARIUS PLATINUM	United Kingdom	AQPBF	Auto	Low
JMAT LN	JOHNSON MATTHEY	United Kingdom	JMPLF	Auto	Low
LXS GR	LANXESS	Germany	LNXSF	Auto	Low
LKQ US	LKQ CORP.	United States	LKQ	Auto	Low
SOLB BB	SOLVAY	Belgium	SVYSF	Auto	Low
3402 JP	TORAY	Japan	TRYIF	Auto	Low
VCT LN	VICTREX	United Kingdom	VTXPF	Auto	Low
Buildings					
IR US	INGERSOLL-RAND	United States	IR	Buildings	High
KNEBV FH	KONE OYJ	Finland	KNYJF	Buildings	High
LR FP	LEGRAND	France	LGRVF	Buildings	High
OC US	OWENS CORNING	United States	OC	Buildings	High
SGO FP	SAINT-GOBAIN	France	CODGF	Buildings	High
CSR AU	CSR LTD	Australia	CSRLF	Buildings	Medium
ELUXB SS	ELECTROLUX	Sweden	ELUXF	Buildings	Medium
GNRC US	GENERAC	United States	GNRC	Buildings	Medium
HD US	THE HOME DEPOT	United States	HD	Buildings	Medium
HON US	HONEYWELL	United States	HON	Buildings	Medium
JCI US	JOHNSON CONTROLS	United States	JCI	Buildings	Medium
LOW US	LOWE'S	United States	LOW	Buildings	Medium
5202 JP	NIPPON SHEET GLASS	Japan	NPSGF	Buildings	Medium
PHIA NA	PHILIPS	Netherlands	PHGFF	Buildings	Medium
UTX US	UNITED TECH	United States	UTX	Buildings	Medium
WHR US	WHIRLPOOL	United States	WHR	Buildings	Low
Industrials & Integrated					
2308 TT	DELTA ELECTRONICS	Taiwan	DLTEF	Industrials & Integrated	High
G1A GR	GEA	Germany	GEAGF	Industrials & Integrated	High
HXL US	HEXCEL CORP	United States	HXL	Industrials & Integrated	High
LR FP	LEGRAND	France	LGRVF	Industrials & Integrated	High
SXS LN	SPECTRIS	United Kingdom	SEPJF	Industrials & Integrated	High
6273 JP	SMC	Japan	SMECF	Industrials & Integrated	High
SPX LN	SPIRAX-SARCO	United Kingdom	SPXSF	Industrials & Integrated	High
ABBN VX	ABB LTD.	Switzerland	ABLZF	Industrials & Integrated	Medium

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Table 8: Global Energy Efficiency Exposure Stock list

Ticker	Name	Country	BofAML Ticker	EE sub-sector	EE exposure
Industrials & Integrated					
ALFA SS	ALFA LAVAL	Sweden	ALFVF	Industrials & Integrated	Medium
ALO FP	ALSTOM	France	AOMFF	Industrials & Integrated	Medium
6367 JP	DAIKIN	Japan	DKILF	Industrials & Integrated	Medium
ELUXB SS	ELECTROLUX	Sweden	ELUXF	Industrials & Integrated	Medium
HON US	HONEYWELL	United States	HON	Industrials & Integrated	Medium
NEX FP	NEXANS	France	NXPRF	Industrials & Integrated	Medium
PHIA NA	PHILIPS	Netherlands	PHGFF	Industrials & Integrated	Medium
SU FP	SCHNEIDER	France	SBGSF	Industrials & Integrated	Medium
SIE GR	SIEMENS	Germany	SMAWF	Industrials & Integrated	Medium
ATCOA SS	ATLAS COPCO	Sweden	ATLKF	Industrials & Integrated	Low
CRG IN	CROMPTON GREAVES	India	CPGZF	Industrials & Integrated	Low
ETN US	EATON CORP PLC	United States	ETN	Industrials & Integrated	Low
HEXAB SS	HEXAGON AB	Sweden	HXGBF	Industrials & Integrated	Low
ISYS LN	INVENSYS	United Kingdom	IVNSF	Industrials & Integrated	Low
MEO1V FH	METSO	Finland	MXTOF	Industrials & Integrated	Low
PRY IM	PRYSMIAN	Italy	PRYMF	Industrials & Integrated	Low
RXL FP	REXEL	France	RXLSF	Industrials & Integrated	Low
SIEM IN	SIEMENS LTD	India	SMNBF	Industrials & Integrated	Low
SKFB SS	SKF	Sweden	SKUFF	Industrials & Integrated	Low
VK FP	VALLOUREC	France	VLOUF	Industrials & Integrated	Low
IT					
ADI US	ANALOG DEVICES	United States	ADI	IT	High
ARM LN	ARM HOLDINGS	United Kingdom	ARMHF	IT	High
ASML NA	ASML NA	Netherlands	ASMLF	IT	High
EMC US	EMC CORP	United States	EMC	IT	High
EQIX US	EQUINIX	United States	EQIX	IT	High
FLTX US	FLEETMATICS	Ireland	FLTX	IT	High
IFX GR	INFINEON	Germany	IFNNF	IT	High
IBM US	IBM	United States	IBM	IT	High
INTC US	INTEL	United States	INTC	IT	High
INXN US	INTERXION	Netherlands	INXN	IT	High
LLTC US	LINEAR TECHNOLOGY	United States	LLTC	IT	High
CRM US	SALESFORCE.COM	United States	CRM	IT	High
6707 JP	SANKEN ELECTRIC	Japan	SANJF	IT	High
SPLK US	SPLUNK	United States	SPLK	IT	High
STM FP	ST	France	STMEF	IT	High
TDC US	TERADATA	United States	TDC	IT	High
TIBX US	TIBCO SOFTWARE	United States	TIBX	IT	High
VMW US	VMWARE INC	United States	VMW	IT	High
AMZN US	AMAZON.COM	United States	AMZN	IT	Medium
CSCO US	CISCO SYSTEMS	United States	CSCO	IT	Medium
AAPL US	APPLE	United States	AAPL	IT	Medium
GOOG US	GOOGLE	United States	GOOG	IT	Low
HPQ US	HEWLETT-PACKARD	United States	HPQ	IT	Low
6502 JP	TOSHIBA	Japan	TOSBF	IT	Low
LEDs & Lighting					
CREE US	CREE	United States	CREE	LEDs & Lighting	High
2448 TT	EPISTAR	Taiwan	EPIPF	LEDs & Lighting	High
2393 TT	EVERLIGHT	Taiwan	EVLEF	LEDs & Lighting	High
046890 KS	SEOUL SEMICONDUCTOR	Korea, Republic Of	SLSOF	LEDs & Lighting	High
VECO US	VEECO INSTR.	United States	VECO	LEDs & Lighting	High
PHIA NA	PHILIPS	Netherlands	PHGFF	LEDs & Lighting	Medium
MXIM US	MAXIM	United States	MXIM	LEDs & Lighting	Low
SIEM IN	SIEMENS LTD	India	SMNBF	LEDs & Lighting	Low
Smart Grid & Storage					
ITRI US	ITRON	United States	ITRI	Smart Grid & Storage	High
MRO LN	MELROSE PLC	United Kingdom	MLSPF	Smart Grid & Storage	High
5333 JP	NGK INSULATORS	Japan	NGKIF	Smart Grid & Storage	High
MXIM US	MAXIM	United States	MXIM	Smart Grid & Storage	High
ABB US	ABB	Switzerland	ABB	Smart Grid & Storage	Medium
ALO FP	ALSTOM	France	AOMFF	Smart Grid & Storage	Medium

18 April 2013

Table 8: Global Energy Efficiency Exposure Stock list

Ticker	Name	Country	BofAML Ticker	EE sub-sector	EE exposure
Smart Grid & Storage					
CSCO US	CISCO SYSTEMS	United States	CSCO	Smart Grid & Storage	Medium
JCI US	JOHNSON CONTROLS	United States	JCI	Smart Grid & Storage	Medium
SU FP	SCHNEIDER	France	SBGSF	Smart Grid & Storage	Medium
SI US	SIEMENS	Germany	SI	Smart Grid & Storage	Medium
ETN US	EATON CORP PLC	United States	ETN	Smart Grid & Storage	Low
GE US	GENERAL ELECTRIC	United States	GE	Smart Grid & Storage	Low
6502 JP	TOSHIBA	Japan	TOSBF	Smart Grid & Storage	Low
SQM US	SQM	Chile	SQM	Smart Grid & Storage	Low
Transport					
BBD/B CN	BOMBARDIER INC.	Canada	YBBD B	Transport	High
CNI US	CANADIAN NATL.	Canada	CNI	Transport	High
390 HK	CRG	China	CRWOF	Transport	High
1766 HK	CSR	China	CSRGF	Transport	High
FGP LN	FIRSTGROUP PLC	United Kingdom	FGROF	Transport	High
GOG LN	GO-AHEAD GROUP	United Kingdom	GHGUF	Transport	High
525 HK	GUANGSHEN RAILWAY	China	GNGYF	Transport	High
NEX LN	NATIONAL EXPRESS	United Kingdom	NXPGF	Transport	High
SGC LN	STAGECOACH GROUP	United Kingdom	SAGKF	Transport	High
VOS GR	VOSSLOH	Germany	VOSSF	Transport	High
3898 HK	ZHUZHOU CSR	China	ZHUZF	Transport	High
CSX US	CSX CORPORATION	United States	CSX	Transport	High
NSC US	NORFOLK SOUTHERN	United States	NSC	Transport	High
UNP US	UNION PACIFIC	United States	UNP	Transport	High
ALO FP	ALSTOM	France	AOMFF	Transport	Medium
1186 HK	CRCC	China	CWYCF	Transport	Medium
YZJ SP	YANGZIJANG	Singapore	YSHLF	Transport	Low

Source: BofA Merrill Lynch Global Research, Bloomberg. *EE exposure = BofA Merrill Lynch Global Research estimates of current sales derived from energy efficiency related products, services, technologies and solutions.

Short-term variations in economic growth have only marginal impacts on long-term energy and climate change trends

The world cannot afford to pay c9% of nominal GDP in energy costs

Short-term variations in economic growth have only marginal impacts on long-term energy and climate change trends

A world in which warming reaches 4°C above preindustrial levels would be one of unprecedented heat waves, severe drought, and major floods in many regions, with serious impacts on human systems, ecosystems, and associated services (source: World Bank)

Energy efficiency, the path to a sustainable energy future

On the path to an unsustainable energy future Without a bold change of policy, the world risks locking itself into an insecure, inefficient and high-carbon energy system. Assuming that actual implementation of intended G20 policies and measures is undertaken in a cautious manner – in line with the IEA’s World Energy Outlook’s central New Policies scenario – primary energy demand is expected to increase by one-third over the period to 2035 with China, India and the Middle East accounting for 60% of the increase. As a result, energy-related CO2 emissions are likely to increase by 20%, following a trajectory consistent with a long-term rise in the average global temperature of 3.6-4.0°C.

Energy efficiency is the easy answer In a fossil fuel and resource-constrained world, energy demand inevitably has to adjust to limited supplies. The rationale is multifold, from supply-demand balance, to energy and infrastructure costs, to energy security, to environmental sustainability, to access to energy and fuel poverty. Barring an outright, long-term economic downturn – we believe that this process needs to occur through a combination of energy efficiency improvements and gradual substitution of oil and fossil fuels. Both of these can help restrain our growing appetite for energy in the long-term - although we believe that energy efficiency offers the single, greatest prospects among currently available options for cheap and easy energy and cost savings.

Global public policy is moving en masse in favour of efficiency A combination of the unsustainability of current and expected energy use, rising energy costs (c9% of nominal GDP) – and a desire to balance energy security with reduced emissions – means that we are seeing intensifying regulatory pressure on energy efficiency. We believe that the recession – which has made “less is more” the watchword of the last few years – is adding to the weight and direction of public policy pressure which is clearly focused on increasing efficiency and decreasing consumption and costs. Energy efficiency is becoming the central plank of governmental energy policy – and new and emerging regulations will increasingly requires companies to improve their energy efficiency – creating significant investment opportunities across buildings, industry, IT, power and transport.

On the path to an unsustainable energy future

The overwhelming majority of climate change experts agree that the earth’s climate system is unequivocally warming, and it is more than 90% certain that humans are causing this through activities that increase concentrations of greenhouse gases (GHGs) in the atmosphere. Without a bold change of policy, the world risks locking itself into an insecure, inefficient and high-carbon energy system.

Energy demand to increase by at least 35% to 2035E

Assuming that actual implementation of intended global policies and measures is undertaken in a cautious manner – under the IEA’s World Energy Outlook’s central New Policies scenario – primary energy demand is expected to increase by 35% between 2010 and 2035. Growth [is expected to] slow from an average of 1.6% per year in the period 2010-20 to 1.0% per year in 2020-35, as measures introduced to meet energy security and climate objectives take effect and as economic and population growth rates drop in the key emerging economies [(source: xx)].

See further our reports on “Extreme Weather” and our CO2 Screening tool

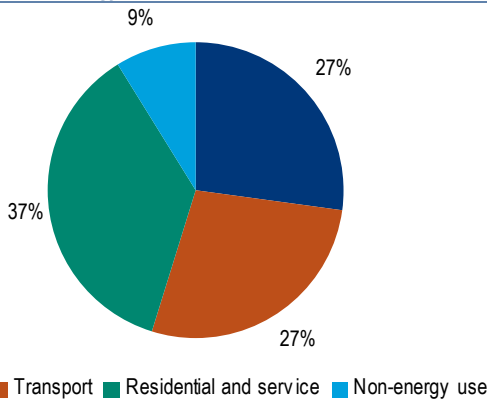
[Extreme Weather, 28 September 2012](#)

[CO2 Screener, 01 March 2013](#)

Irreversible climate change is becoming a reality

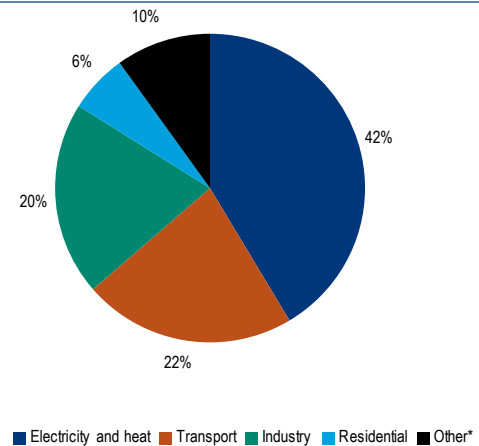
As a result, without further commitments and actions to reduce GHGs, the world is set to get warmer by 3.6-4.0°C than the pre-industrial era climate (source: IEA, World Bank) vs the 2.0°C critical threshold considered by scientists an adequate means of avoiding dangerous climate change. Even with full implementation of mitigation commitments and pledges, there is a 20% chance of exceeding 4°C by 2100. If such commitments are not met, scientists are now nearly unanimously predicting a 4°C increase by 2100, or even as early as the 2060s (source: World Bank).

Chart 3: World total energy consumption - 2009



Source: IEA, BofA Merrill Lynch Global Research

Chart 4: World CO2 emissions - 2010



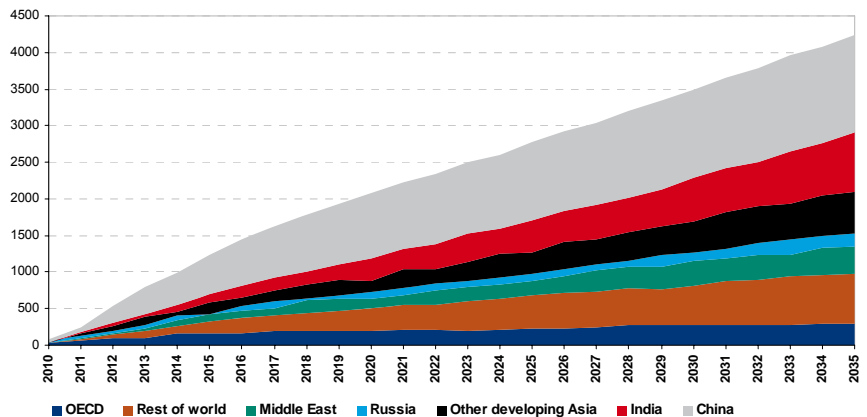
Source: IEA, BofA Merrill Lynch Global Research

Average energy consumption per capita in IEA member countries is 5 toe/year or 2x the global average and 8x India. But IEA countries have the lowest energy intensity due to higher GDP per capita and the impact of energy efficiency implementation (source: IEA).

90% of energy demand growth in non-OECD

90% of the projected growth in global energy demand will come from emerging markets. China, India and the Middle East will account for 60% of the increase in energy demand between 2010 and 2035. China alone is set to be the world’s largest energy consumer by 2035, consuming 77% more than the US (even if its per capita demand will still be 52% lower). Brazil, India, Indonesia and the Middle East will see energy demand grow even faster than China to 2035. EMs also dominate the expansion of supply of fossil fuels (source: IEA).

Chart 5: Global energy demand increases by one-third from 2010 to 2035 (Mtoe)

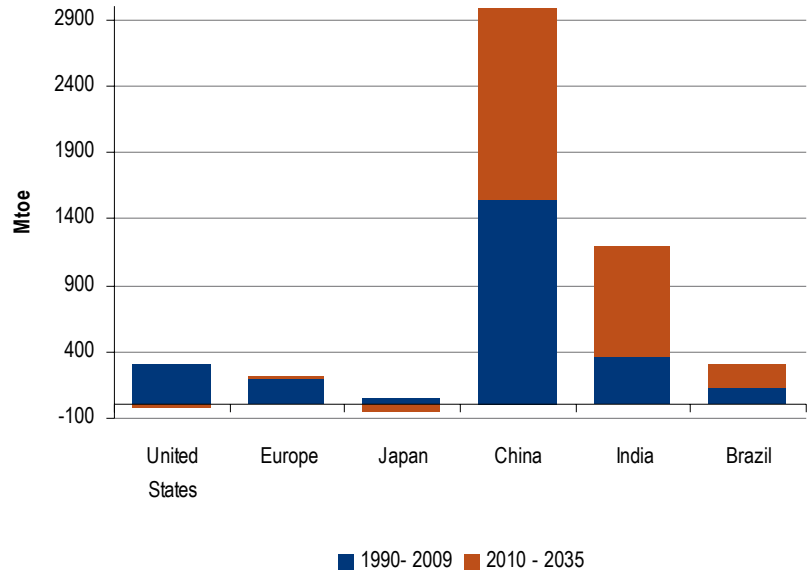


Source: EA WEO 2011, BofA Merrill Lynch Global Research

Demand is set to grow for all energy sources

Positively, from a climate change perspective, the share of fossil fuels in global primary energy consumption is set to fall from around 80% today to 70% in 2035. In 2035, the share of renewables (including traditional biomass) in world primary energy demand should reach 18%, from 13% in 2010. However, the IEA's central scenario assumes growth in world demand for all energy sources to 2035.

Chart 6: Additional primary energy demand to 2035 (Updated)



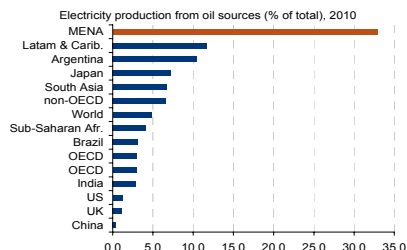
Source: EIA WEO 2012

- **Coal use to rise by 21%** by 2035 vs 2010, largely driven by emerging markets.
- **Oil demand increases by 13%** largely driven by transport.
- **Gas gains in importance:** Gas' share in the energy mix is expected to rise – with absolute growth similar to coal and oil combined - and its use is set to catch up with total global coal consumption.
- **Renewables increase from 13% to 18% of the mix in 2035** with the growth accounting for half of new installed capacity, but continuing to be underpinned by subsidies; while relative growth is faster than any other energy form; absolute renewables supply is still not close to the level of any single fossil fuel by 2035.
- **Nuclear generation grows by 58%** driven by China, India and South Korea (source: IEA).

Table 9: World primary energy demand by fuel in the New Policies Scenario (Mtoe)

	1990	2010	2015	2020	2030	2035	2010-35*
Coal	2,231	3,474	3,945	4,082	4,180	4,218	0.80%
Oil	3,230	4,113	4,352	4,457	4,578	4,656	0.50%
Gas	1,668	2,740	2,993	3,266	3,820	4,106	1.60%
Nuclear	526	719	751	898	1,073	1,138	1.90%
Hydro	184	295	340	388	458	488	2.00%
Bio energy	903	1,277	1,408	1,532	1,755	1,881	1.60%

Table 10: MENA generates 30% of its power from oil, far greater than other EMs whose use of oil in electricity averages 7%



Source: WB, BofA Merrill Lynch Global Commodity Research

See further our Global Commodities team's "Medium-term oil outlook" [Global Energy Paper, 18 February 2013](#)

Table 9: World primary energy demand by fuel in the New Policies Scenario (Mtoe)

	1990	2010	2015	2020	2030	2035	2010-35*
Other renewables	36	112	200	299	554	710	7.70%
Total	8,779	12,730	13,989	14,922	16,417	17,197	1.20%

Source: IEA, BofA Merrill Lynch Global Research

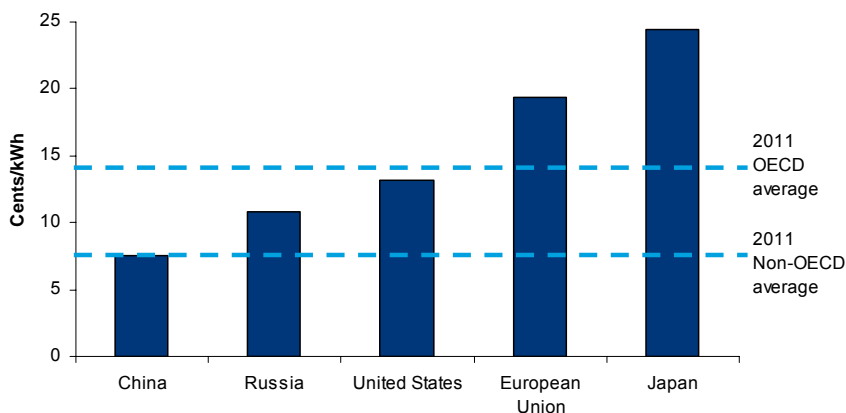
Energy for electricity remains fastest-growing sector

Global demand for electricity is set to continue to grow faster than demand for any other final form of energy until 2035. It is expected to grow at 2.2% pa to 2035, of which more than 80% is attributable to non-OECD countries. Total electricity consumption is forecast to be 72% higher in 2035 than in 2010. Electricity continues to gain share in final energy use, meeting one-third of non-transport energy demand in 2030 (vs 28% in 2011) (source: BP). Power generation capacity additions are projected to total 3,900GW by 2035, with the largest additions in China (source: IEA). Energy used to generate electricity is expected to account for 57% of the projected growth in primary energy consumption to 2030 (vs 54% for 1990-2010) (source BP).

High electricity prices are here to stay

Electricity prices are set to increase to 2035 with the highest prices persisting in the EU & Japan, well above those in China, Russia & the U.S. (source: IEA).

Table 11: Average household electricity prices, 2035



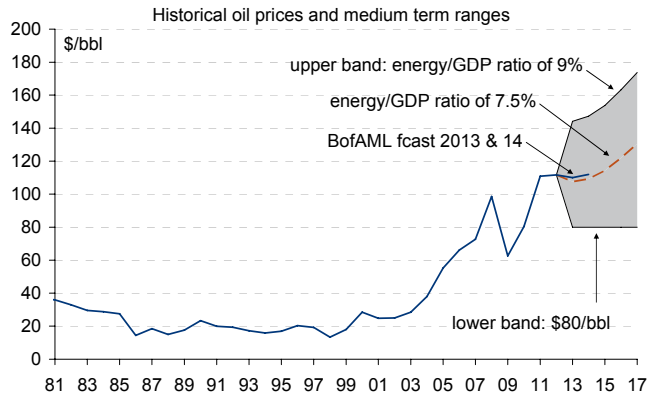
Source: IEA WEO 2012

High oil prices are here to stay

High oil prices are unlikely to be a temporary phenomenon with the oil market balance deteriorating in the medium- to long-term according to our BofAML Global Commodities Research team:

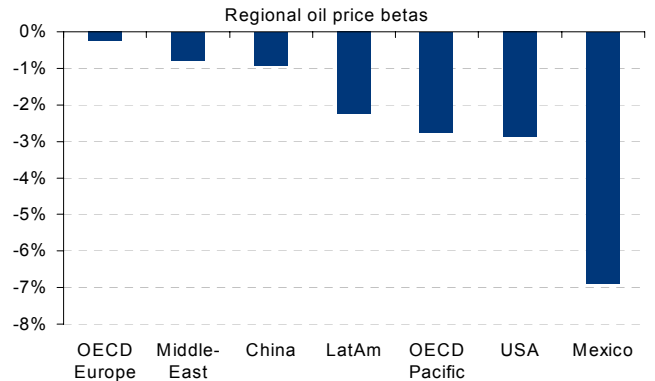
- **Strong floor for Brent oil prices at US\$80/bbl until 2017** - Brent crude oil prices have averaged around US\$110/bbl in the last two years. In our view, Brent crude oil prices will stay in the US\$100-130/bbl range on average through 2015. Looking at the downside risks, we believe Brent crude oil prices are unlikely to fall below an average of US\$80/bbl for three reasons: (1) rising full-loaded production costs for marginal projects in non-OPEC areas, (2) rising government budget breakeven levels for key OPEC countries, and (3) price elasticity of demand which suggests consumption would increase strongly at such low prices. In the US, however, surging shale output creates a risk of US\$50/bbl WTI on an 18-24 month horizon.

Chart 7: In our view, Brent crude oil prices will likely stay in the US\$100 to US\$130/bbl range on average through 2015



Source: Bloomberg, IMF, BP, IEA, BofA Merrill Lynch Global Commodities Research

Chart 8: Given our estimates for price elasticity of demand, we would expect consumption to increase strongly at US\$80/bbl oil

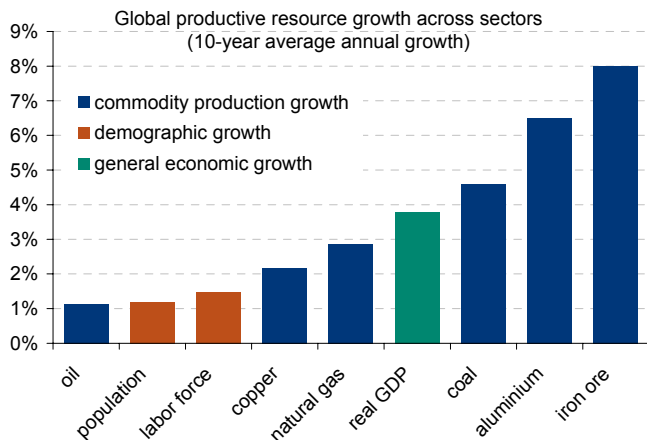


Source: BofA Merrill Lynch Global Commodities Research

The world economy can hardly afford to spend more than 9% of its GDP on energy

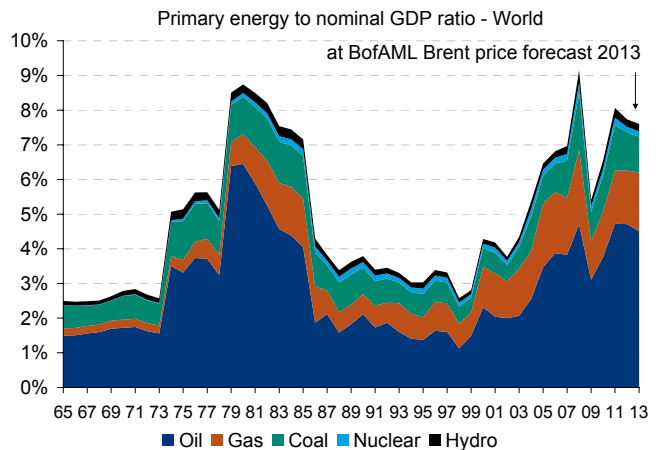
- **Brent is capped at US\$140/bbl in 2013, US\$175 in 2017** - So both OPEC and non-OPEC international barrels have a strong floor at US\$80/bbl from a supply perspective, but risks could remain skewed to the upside as long as the Fed maintains an aggressive QE program. Given the supply constraints, Brent prices are likely to rise at a faster rate than the prices of other factors of production in the economy. With major demand destruction episodes likely to occur when energy consumption as a share of nominal GDP reaches 9%, we see a cap on prices at US\$140/bbl this year. This number could rise slowly in line with global GDP and the relative scarcity of crude oil to US\$175/bbl in 2017.

Chart 9: Brent prices are likely to rise at a faster rate than the prices of other factors of production in the economy



Source: BP, BofA Merrill Lynch Global Commodities Research

Table 12: Major demand destruction episodes are likely to occur when energy consumption as a share of nominal GDP reaches 9%



Source: IMF, IEA, BP, Bloomberg, BofA Merrill Lynch Global Commodities Research

- **Demand rationing continues in a supply-constrained world** - While Germany, France, Italy and the UK listed among the world's 10 largest oil consumers in 1995, today their spots have been taken by Saudi Arabia, Brazil and India. Put simply, countries that fail to generate enough income to pay for their energy use had to cut back their intake in favour of China, India or Brazil. Thus, the non-OECD block is set to increase its oil consumption to

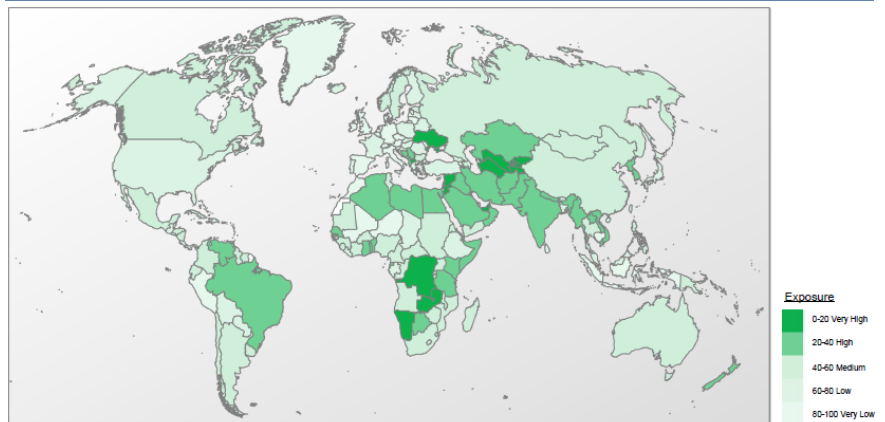
47 million b/d by 2014, from 33 million b/d ten years ago. In contrast, shrinking populations in DMs are set to accelerate the ongoing oil demand contraction in the OECD. Overall we expect global oil demand to grow by 6.3 million b/d to 2017.

- **North America leads non-OPEC supply growth medium-term** - On the non-OPEC supply side, we have increased our expectations largely on North America. On our revised estimates, we expect non-OPEC oil supply to grow by a cumulative 3.9 million b/d from 2012 to 2017. The US will be by far the largest contributor to growth, adding 3.1 million b/d from 2012 to 2017. Of course, Canadian oil sands and ongoing developments in Brazil should also contribute significantly to non-OPEC oil supplies over the next 5 years. We expect the gap between non-OPEC supply and global oil demand in the medium term to be filled by OPEC barrels, mostly coming from Iraq's contribution of 1.9 million b/d by 2017.

US\$38tn in future energy investments needed to 2035

The expected growth in world demand in 2035 would mean that US\$38tn in global investment in energy-supply infrastructure is required from 2011 to 2035, an average of US\$1.5tn per year. Oil and gas combined would be the biggest recipient, requiring nearly US\$20tn on the back of higher costs and a need for more upstream investment. The power sector would claim nearly US\$17tn of the total investment. Coal and biofuels account for the remaining investment. Two-thirds of the global amount is required in emerging markets (source: IEA).

Chart 10: High global energy infrastructure needs

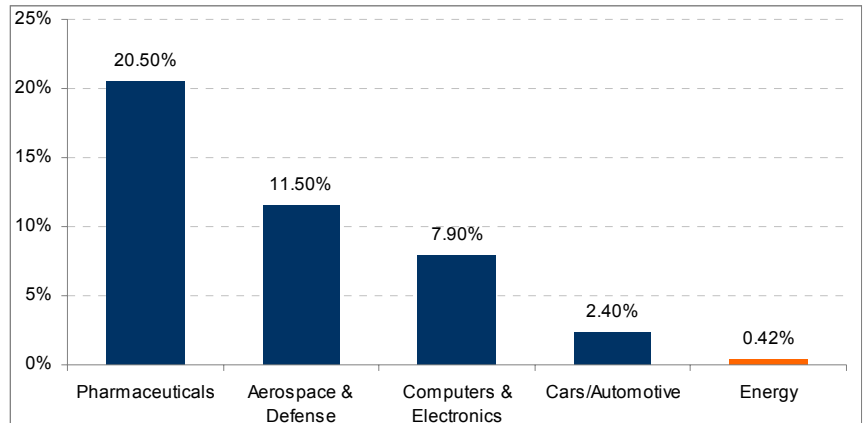


Source: CAMRADATA

Need to step up private investment

It is essential, in our view, that the private sector steps up its level of R&D in energy – with a consequent reduction in government investment. For instance, in the US, private investment in energy R&D (as a % of sales) was only 4.2% in 2012, compared with 20.5% for pharmaceuticals and 11.5% for aerospace & defence (source: American Energy innovation Council).

Chart 11: Low private investment in energy R&D (as % of sales)



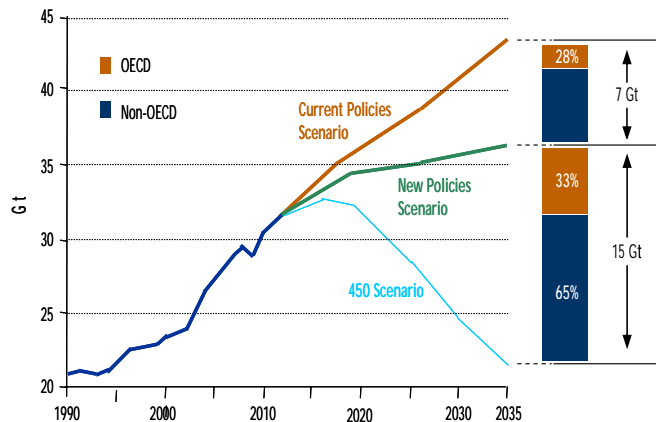
Source: American Energy Innovation Council, Catalyzing American Ingenuity, 2012, BofA Merrill Lynch Global research

At the current pace, cumulative CO2 emissions over the next 25 years will amount to three-quarters of the total from the past 110 years - and China's per-capita emissions will match the average of OECD countries (source: IEA)

Irreversible climate change is becoming a reality

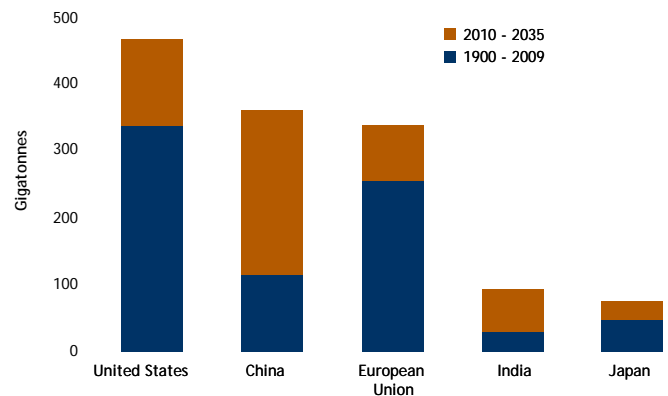
As things stand – under the IEA's central “New Policies” scenario – rising fossil energy use will lead to irreversible and potentially catastrophic climate change. Global energy-related emissions of CO2 grew by 5.3% in 2010 to a record 30.4Gt. Under this scenario, emissions would rise by 20% to 2035, reaching 36.4Gt. This trajectory would be consistent with a long-term global temperature increase of up to 4.0°C (source: IEA, World Bank).

Chart 12: IEA CO2 emissions scenarios to 2025



Source: IEA, BofA Merrill Lynch Global Research

Chart 13: Cumulative energy-related CO2 emissions in selected regions



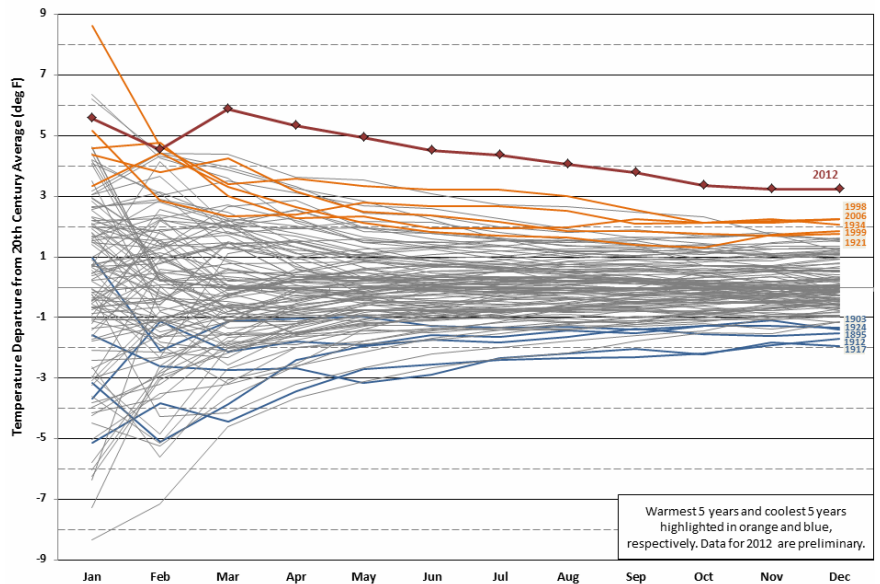
Source: EA, BofA Merrill Lynch Global Research

4° would have devastating consequences

According to the World Bank's 2012 “Turn Down the Heat – Why a 4°C Warmer world Must be Avoided” report:

“The 4°C scenarios are devastating: the inundation of coastal cities; increasing risks for food production potentially leading to higher malnutrition rates; many dry regions becoming dryer, wet regions wetter; unprecedented heat waves in many regions, especially in the tropics; substantially exacerbated water scarcity in many regions; increased frequency of high-intensity tropical cyclones; and irreversible loss of biodiversity, including coral reef systems. And most importantly, a 4°C world is so different from the current one that it comes with high uncertainty and new risks that threaten our ability to anticipate and plan for future adaptation needs.”

Chart 14: 2012 was the warmest year for the contiguous U.S. since 1895: 3.3°F above average



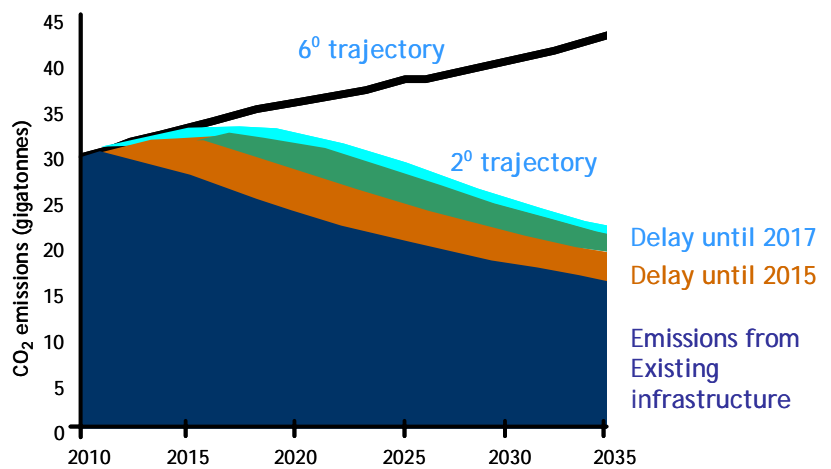
Source: NOAA's National Climatic Data Center., BofA Merrill Lynch Global Research

Short-term, lower rates of economic growth would only have minimal impact on these energy and climate trends.

6° would be even more dangerous

Were new policies not implemented, we could be on an even more dangerous path, to an increase of 6°C – which would be significantly higher than the globally agreed goal of an increase of 2°C (which would require the long-term atmospheric concentration of GHGs in the atmosphere to be limited to 450 parts per million (ppm) of CO₂-eq (source: IEA).

Chart 15: CO₂ emissions temperature trajectories to 2035



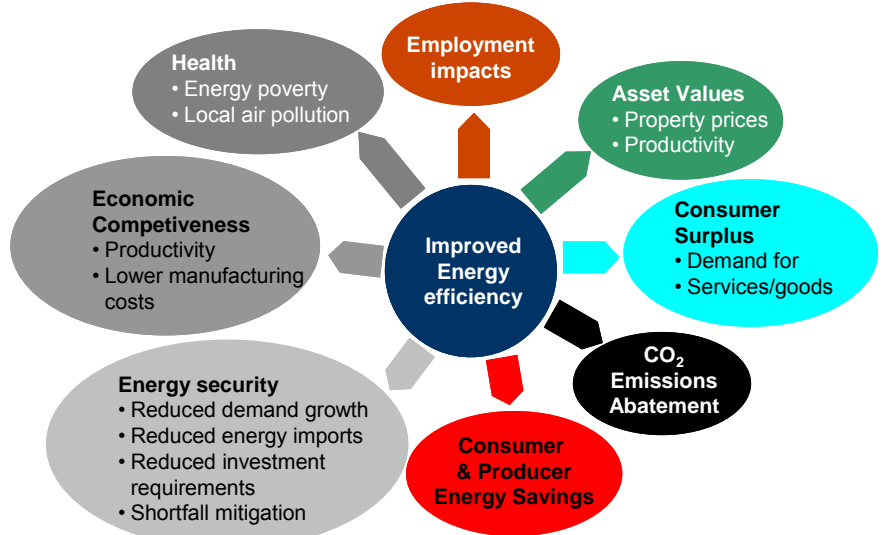
Source: IEA WEO 2011

Energy efficiency is the answer

In a fossil fuel and resource-constrained world, energy demand inevitably has to adjust to limited supplies. The rationale is multifold from supply-demand balance, to energy and infrastructure costs, to energy security, to environmental sustainability, to access to energy and fuel poverty. Barring an outright, long-term economic downturn, we believe that this process needs to occur through a

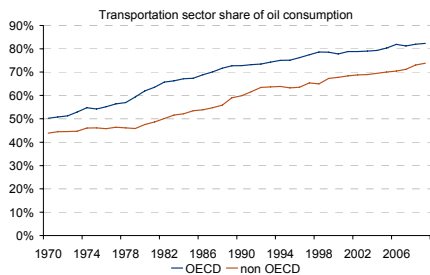
combination of energy efficiency improvements and gradual substitution out of oil and fossil fuels. Both of these can help restrain our growing appetite for energy in the long-term - although we believe that energy efficiency offers the single, greatest prospects among currently available options for cheap and easy energy and cost savings.

Chart 16: Benefits of improved energy efficiency



Source: IEA, BofA Merrill Lynch Global Research

Chart 17: Oil is primarily a transportation fuel



Source: IEA, BofA Merrill Lynch Global Research

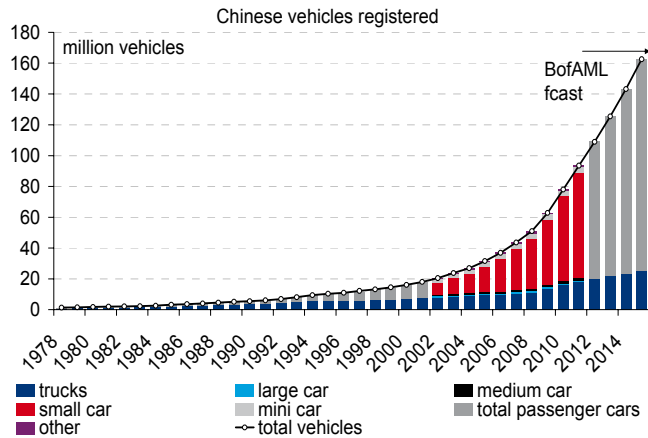
Substitution offers limited near-term prospects

Oil (c.30% of energy demand) is primarily a transportation fuel. In absolute terms, our Global Commodities Research team finds that oil consumption growth over the medium term to 2016 will be driven entirely by EMs, with rapid income growth, expanding car fleets and urbanization underpinning strong oil demand growth. On its estimates, emerging markets, which already accounts for half of global output, will also overtake the OECD in 2014 in terms of oil consumption. Global oil demand is poised to increase from 89.8m b/d in 2012 to 96.1m b/d in 2017.

As seen in the Autos section of this report, even if the technology were to allow for substitution out of oil in transportation, via natural gas-powered vehicles or plug-in hybrid vehicles, there is limited scope for large-scale substitution unless energy policies set the right incentives and until the necessary infrastructure and distribution systems are developed. Thus, oil efficiency improvements will hinge in the near term on fuel efficiency advancements in transportation and upgrading of the fleet, while in the longer term they will probably be contingent on game-changing technologies.

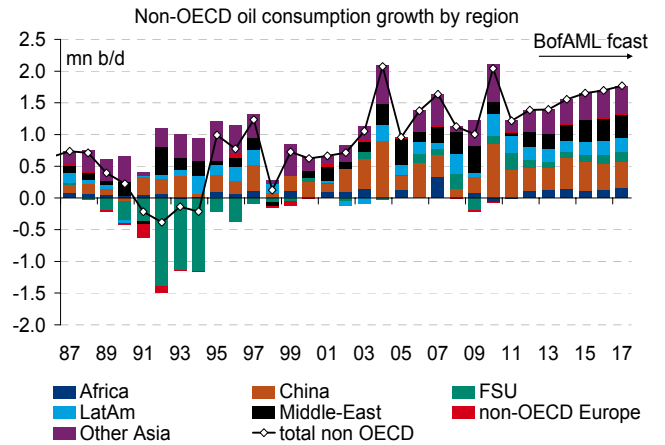
18 April 2013

Chart 18: In contrast to the trends in developed markets, Chinese cars are getting bigger and more fuel intensive



Source: JD Power, BofA Merrill Lynch Global Research
Note: 2013-14 represent BofAML forecasts, 2014+ are projections from JD Power.

Chart 19: We see oil demand growth of about 0.42m b/d YoY in each year from 2015 to 2017



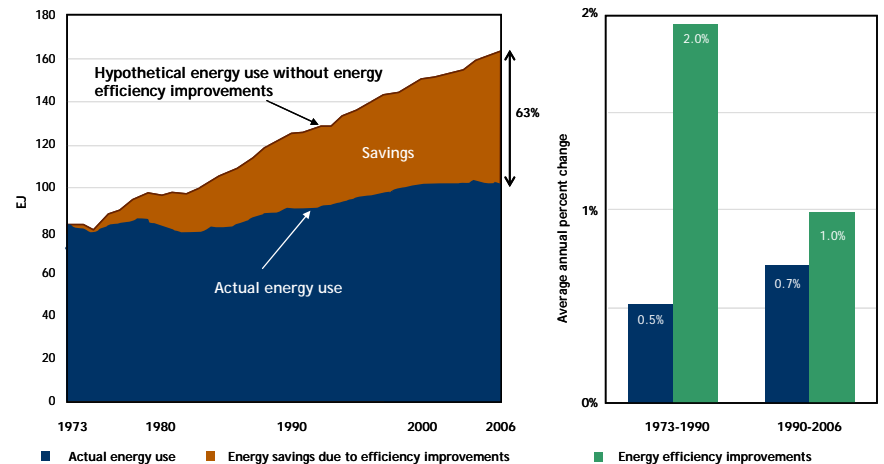
Source: IEA, BofA Merrill Lynch Global Commodity Research

An average fridge sold today uses under 700kWh/year vs 2,000+ in 1973

End use efficiency, 30Y track record of success

We believe that end use energy efficiency offers the greatest potential to reduce energy use, energy costs and emissions across sectors. Its historical track record bears witness in this regard. Without the savings from improved energy efficiency – notably across buildings, industry, power and transport – since 1973, global energy consumption would now be at least 63% higher in IEA countries. This is the equivalent of 59 EJ (exajoule) of energy not consumed and 4.2Gt CO₂ - and has played an integral role in restraining the overall growth of primary energy consumption.

Chart 20: Historical impact of energy efficiency* (1973-2006)



Source: IEA. * Based on the historical impacts for EA 11, a group of 11 IEA countries which have statistics available over the 40 past years. The countries sampled account for ~ 80% IEA energy consumption

Globally, the level of total primary energy supply (TPES) required for each unit of GDP has fallen. Since 1974; global energy demand rose by 100% vs a 170% growth in GDP vs 69% growth in population (source: IEA).

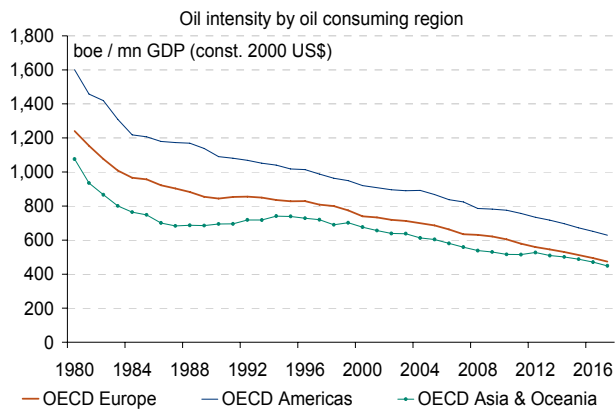
Energy consumption per unit of GDP falls as lighter service industries grow in importance and thus the relationship between oil consumption and development plateaus at higher levels of development

Oil intensity has been on a 30Y decline

Our Global Commodities Research team notes that global oil intensity of GDP – ie, the amount of oil consumed for each unit of real GDP produced – has been falling steadily in the OECD for the past 30 years due to technological advancements. Even China’s oil intensity peaked several decades ago during the early stages of industrialisation and is now falling steadily despite ongoing urbanisation and the proliferation of vehicle ownership. Only the Middle East bucks the trend.

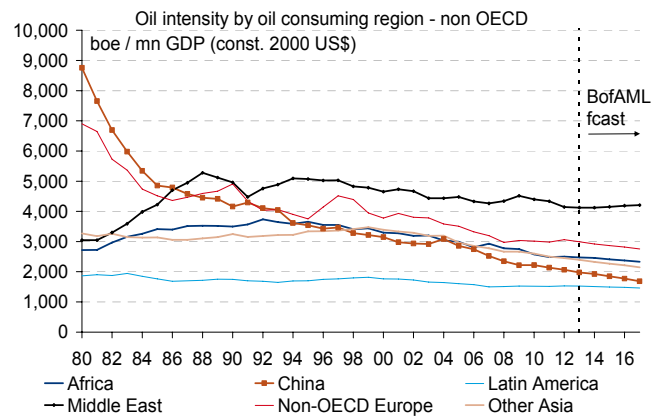
Energy intensity has a non-linear relationship with income growth. At early stages of development, heavy industries grow strongly, taking up a larger share of the total economy as countries industrialise. As an economy moves from an industrializing to an advanced service economy, intensity of all energy types tends to decline. Of course, the process is not just dependent on economic growth. With the help of technological advancements in transportation, industrial processes, buildings and consumer appliances, energy intensity continues to decline in advanced economies.

Chart 21: Oil intensity of GDP keeps falling steadily in the OECD as technological advancements make oil ever more productive



Source: BP, IEA, IMF, BofA Merrill Lynch Global Commodities Research

Chart 22: The Middle East, however, continues to buck the trend even among its EM peers, having persistently high oil intensity



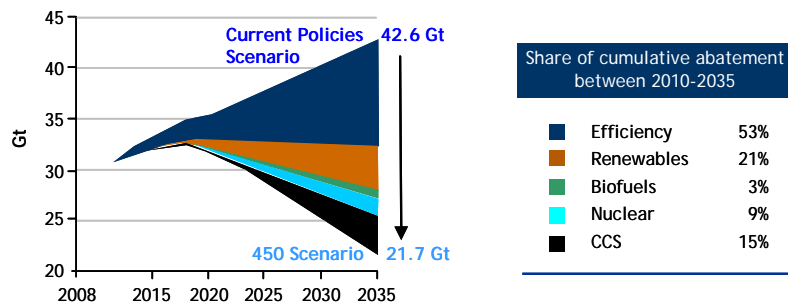
Source: BP, IEA, IMF, BofA Merrill Lynch Global Commodities Research

The biggest challenge will be ensuring action by EMs. The IEA’s 450 Scenario envisages EM carbon taxes in the range US\$20-45 per tonne in 2020, rising to US\$95-120 for all countries by 2035

Greatest potential for energy, cost & CO2 savings to 2030-5

End-use energy efficiency offers the largest greatest potential of any current technology to contribute to CO2 emissions abatement by 2030-35, accounting for over 50% of the total CO2 savings in the IEA’s 450 Scenario. Under this scenario, we would see relatively optimistic implementation of national energy plans and pledges made by countries, including on their future emissions of GHGs.

Chart 23: World energy-related CO2 emission savings by technology in the 450 Scenario



Source: IEA WEO

Under this scenario – which the IEA has called “the pathway to Green Growth” – global CO2 pledges and resolutions (eg, Copenhagen, Cancun, and Durban) would be acted on to alter the trajectory of the global energy system.

- **Fossil fuel use and CO2 emissions peak before 2020**, and energy-related CO2 emissions would be reduced to 3.8Gt, just 6% higher in 2020 than in 2007.
- **GHG emissions stabilise at 450 ppm of CO2-eq by 2035**, in line with an increase in global temperature of around 2°C (and back to 1990 levels).
- **China & the US offer greatest abatement potential**. Geographically, China would account for 32% of abatement, followed by the US at 18%, EU at 8%, India at 7%, Middle East at 4%, Russia at 4%, and Rest of World at 27%.
- **Fuel savings would offset investments**. Incremental investments of US\$10tn from 2010-30 would be needed, equivalent to 0.5% of global GDP in 2020, rising to 1.1% of GDP in 2030. Energy savings of US\$8.6tn across buildings, industry and transport would be achieved to 2030.

Doubling US energy productivity would save US\$494bn/year

Doubling US energy productivity to 2030 with currently available technologies would both reduce the amount of energy needed to run the American economy and the price of energy for US consumers, lowering overall energy costs by US\$494bn a year. Net of investment costs, annual savings to American households, businesses, and government agencies would total US\$327bn, and economic growth and energy demand would be decoupled for the first time in recent history (source: ACNEE).

Table 13: Annual costs and benefits of doubling US energy productivity

By Sector	Investment costs	Energy savings	Net savings
Buildings	US\$72bn	US\$167bn	US\$95bn
Industry	US\$15bn	US\$109bn	US\$94bn
Transportation	US\$79bn	US\$218bn	US\$139bn
Total	US\$166bn	US\$494bn	US\$327bn
By Consumer			
Households	US\$97bn	US\$241bn	US\$145bn
Businesses	US\$61bn	US\$230bn	US\$169bn
Government	US\$9bn	US\$22bn	US\$13bn
Total	US\$166bn	US\$494bn	US\$327bn

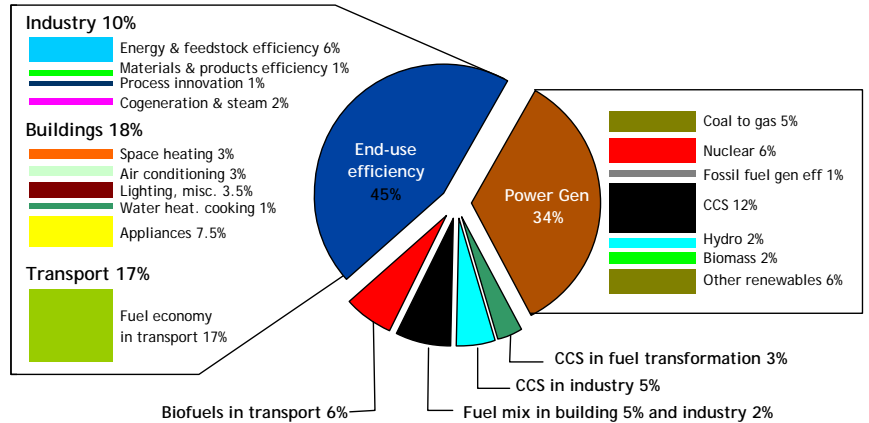
Source: Alliance Commission on National Energy Efficiency Policy 2013

The greatest potential savings from end-use efficiency is in EMs.

Huge savings across buildings, industry, power & transport

As we shall see throughout the report, there is huge scope for end use energy efficiency improvement – both to reduce energy use and costs – across the buildings, industry, power and transport sectors.

Chart 24: 2050 – 32Gt of CO2 abatement reduction potential*

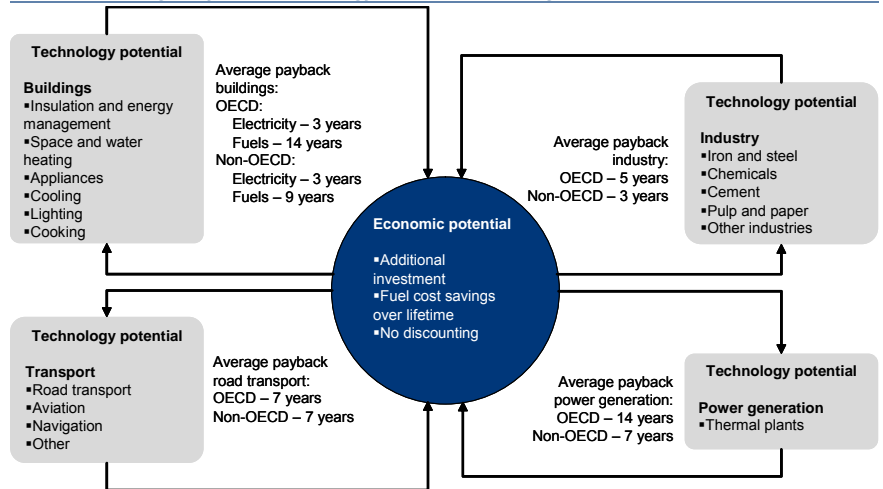


Source: IEA. * Under the IEA's ACT (Accelerated Technology Scenarios) which assumes relatively optimistic uptake of end-use efficiency and other abatement technologies

Short paybacks & negative CO2 abatement costs

Energy efficiency investments in buildings, industry and transport have short payback periods and negative abatement costs. The energy / fuel cost savings over the lifetime of the capital stocks often outweigh the additional capex costs of the efficiency measure, even when future savings are discounted – while enabling significant CO2 abatement potential.

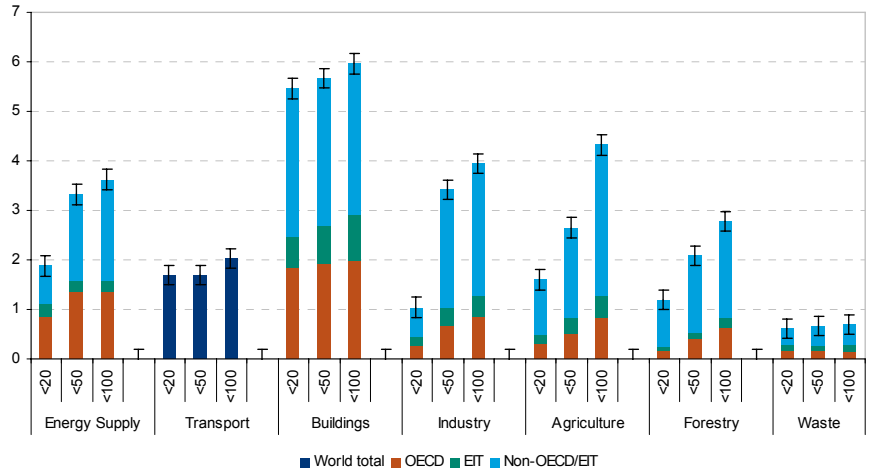
Chart 25: Average paybacks for energy efficient technologies



Source: : IEA WEO Outlook 2012

The chart below shows sectoral estimates of the economic mitigation potential of using technologies and practices expected to be available by 2030, at various costs in US\$ per tCO2-eq. Buildings offer the greatest potential for short paybacks and negative abatement costs – with huge potential across sectors for significant CO2 savings for less than US\$20 or US\$50/tCO2-eq.

Chart 26: Buildings have the greatest CO2 mitigation potential to 2030 (potential at <US\$100, <US\$50, <US\$20 per tCO2-eq)



Source: UN IPCC, BofA Merrill Lynch Global Research

World electricity demand (2.6% p.a.) is projected to grow more rapidly than total energy over the next 20 years, although not as rapidly as GDP. Efficiency gains in power generation mean that the fuel inputs grow less rapidly than power output, averaging 2.1% p.a. 2010-30 (source: BP)

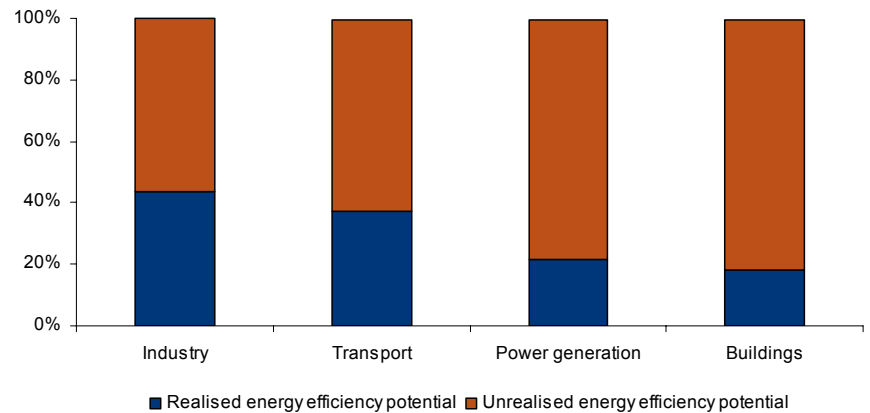
Efficiency is key to controlling demand growth

Annual gains from energy efficiency averaged an impressive 1.9% from 1974-1990, but lower energy prices and a slowdown in energy efficiency implementation have seen this fall to 1% since 1990. But energy efficiency has been stepped up in the past few years and is expected to reach 2.0% globally per year going forward to 2030/5, with improvements across almost all key countries and regions. This acceleration is key to the sustainability of energy, in that it controls the overall growth of primary energy. Energy efficiency gains and a long-term structural shift away from industry and toward less energy-intensive activities – first in rich and then in newly industrialised economies – underpins this trend.

Huge opportunity going unrealised

Two-thirds of the economic potential to improve energy efficiency remains untapped in the period to 2035 (source: IEA)

Table 14: Realised & unrealised energy efficiency potential



Source: IEA WEO 2012

The average cost of an energy efficiency kWh in the US is US\$0.027/kWh compared with the average retail rate of US\$0.097/kWh (source: National Academy of Sciences)

Cost is the key driver, US\$1 invested is US\$2-4 saved

Globally, we believe that we need to get back on track on energy efficiency, for no other reason than cost. A common rule of thumb is that every dollar spent on energy efficiency appliances, buildings, equipment and expenditures avoids more than US\$2 of investment in electricity supply, and saves up to US\$4 in lifetime energy expenditures.

88% of manufacturers realise efficiency is key to business success

An estimated 88% of manufacturers say industrial energy efficiency will be a critical success factor for their business in the coming two decades, largely for reasons of cost competitiveness, especially for energy-intensive sectors. With sub-optimal efficiency practices widespread across industry, there is huge potential for energy, cost and CO2 reductions, with 59% of manufacturers citing the price of energy as one of the biggest factors (source: ABB).

Table 15: How significant are the following in your organization's energy efficiency decisions

2011	2010	Drivers of efficiency	EU	NAm	China	India
1	1	Energy cost savings	1	1	1	1
4	2	Government/utility incentives/rebates	2	3		2
3	3	Enhanced brand or public image				3
NA	4	Increasing energy security	3	2	2	
2	4	GHG reduction				
6	6	Existing policy			3	

Source: Institute for Building Efficiency, initiative of Johnson Controls. * Based on the 2011 Energy Efficiency Indicator (EEI) is the fifth annual survey of global executives and building owners responsible for energy management and investment decisions in commercial and public-sector buildings

Trillion dollar potential energy cost savings

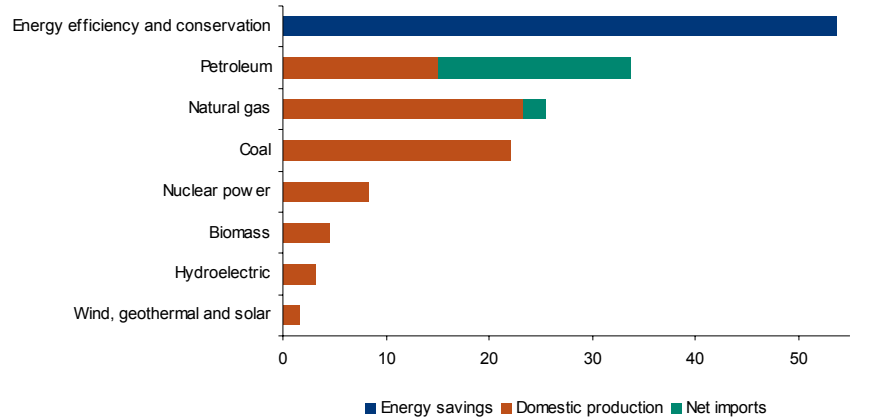
Investments in energy efficiency will be more than offset by lifecycle savings in energy costs. Globally, the most work in this regard has been done on the US market, where it is estimated that a potential 23% reduction in annual energy consumption by 2020 could be achieved via a US\$520bn investment through 2020. This would translate to approximately US\$1.2tn in gross energy savings (source: McKinsey).

The energy independence/security link

The recent US boom in domestic oil and natural gas supply is reducing its dependence on imported energy. According to the Alliance Commission on National Energy efficiency Policy, doubling energy productivity would accelerate this process. It estimates that doubling US energy productivity to 2030 would reduce net energy imports to 7% of US consumption (vs 19% in 2013). More importantly, it argues that it would make the US economy more resilient to energy price spikes. Even if net its energy imports declined to zero, the US would remain vulnerable to global supply disruptions. But by doubling energy productivity, the direct economic cost of a global price spike would be reduced by up to 30% (source: ACNEE).

Doubling US energy productivity, would reduce the direct economic cost of a global price spike by up to 30% (source: ACNEE)

Chart 27: US energy resources used in 2011



Source: Alliance to Save Energy 2013

3bn of the world's "energy poor" suffer the health consequences of inefficient combustion of solid fuels in inadequately ventilated buildings, as well as the economic consequences of insufficient power for productive income-generating activities and for other basic services such as health and education

Key to fighting poverty and enhancing prosperity

The link between a well-performing energy system and lifting up the world's poor is well established. Those countries with underperforming energy systems lose up to 2% of growth potential annually due to electric power outages and inefficient use of scarce energy sources (source: World Bank). The UN has specifically recognised the role that energy efficiency can play as a solution with the Secretary General's Advisory Group on Energy and Climate Change looking to reduced energy intensity as one of its two key policy recommendations.

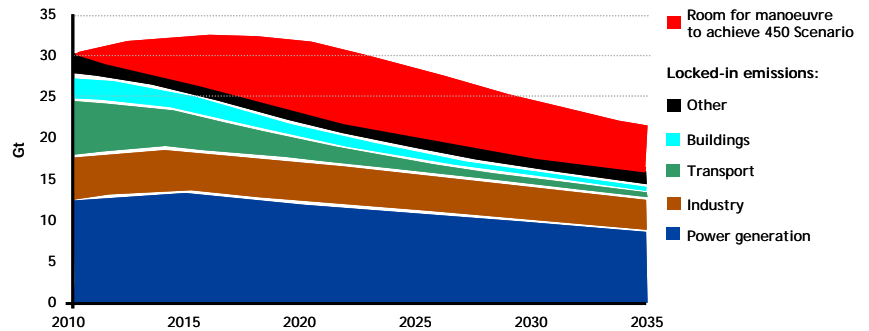
The challenge is partly financial, with an additional US\$30-35bn of energy efficiency capital required for low-income countries and US\$140-170bn for middle-income countries annually until 2030, above the IEA's reference case. Moreover, while most energy efficiency investments are cost-effective, the costs of energy efficiency are typically front-loaded, with the benefits accruing over time. This means that low-income countries and their consumers often have access to only limited and expensive capital and energy options (source: UN).

Delaying action is a false economy

There is an inherent danger in waiting too long to act on energy efficiency. For instance, under the IEA's 450 Scenario – which would limit temperature rises to 2°C – 80% of the total energy-related CO2 emissions to 2035 are already locked in by existing capital stock (ie, building, industry, power stations). Without further action by 2017, the energy-related infrastructure then in place would generate all the CO2 emissions allowed in the Scenario up to 2035. As a result, the IEA argues that delaying action and investment on energy efficiency is a false economy, because for every US\$1 of avoided efficiency investments in the power sector before 2020, an additional US\$4.30 would need to be spent after 2020 to compensate for the increased emissions (source: IEA).

"Governments need to introduce stronger measures to drive investment in efficient and low-carbon technologies. The Fukushima nuclear accident, the turmoil in parts of the Middle East and North Africa and a sharp rebound in energy demand in 2010 which pushed CO2 emissions to a record high, highlight the urgency and the scale of the challenge." (source: IEA)

Chart 28: Locked-in CO2 emissions vs room for manoeuvre to achieve 450 Scenario



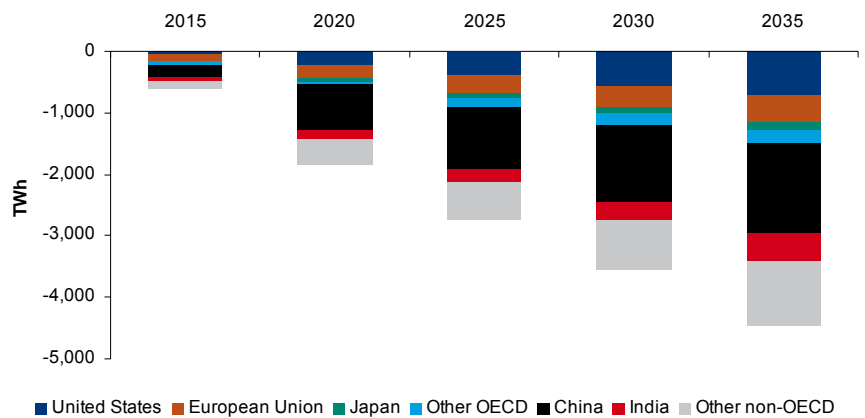
Source: IEA WEO 2011

A best-case efficiency scenario would be a game changer

There is huge potential based on a very optimistic scenario that assumes that all investments capable of improving energy efficiency are made as long as they are economically viable and any market barriers to their realisation are removed (the IEA's "Efficient World" scenario):

- **Global energy demand would increase by only 18% by 2035** from current levels (vs 35% in the New Policy Scenario and 43% in the Current Policy Scenario).
- **Fossil fuels' share of primary energy consumption would fall to 74% in 2035** vs 81% in 2010 as oil demand peaks before 2020; coal demand would be lower in 2035 than today and natural gas demand would grow at a 1% CAGR until 2035.
- **Global energy intensity (in GDP terms) would fall by 2.4% pa** on average over the period 2011-35, and end up 45% below the 2010 level. This would be led by the US, with an average annual drop in energy intensity of 3.0%, followed by 3.2% in non-OECD regions, 3.7% in India and 4.2% in China.
- **The global economy would be boosted by US\$18tn by 2035**, with 0.4% higher global GDP than in the New Policies Scenario and additional investments (+US\$10.6tn vs the NPS is more than offset by the derived US\$16.6tn fuel cost savings).
- **CO2 emissions would peak before 2020 and decline to 30.5 GT in 2035**; roughly flat vs 2010 levels, a trajectory that is likely to be consistent with a long-term average global temperature increase of 3°C (source: IEA)

Chart 29: Potential reduction in electricity demand in the IEA's "Efficient World Scenario" (vs New Policies Scenario)



Source: IEA WEO Outlook 2012

73% of executives expect to increase expenditure on energy efficiency in the coming three years (source: ABB)

Public policy shift in favour of efficiency

A combination of the unsustainability of current and expected energy use, rising energy costs and a desire to balance energy security with reduced emissions means that we are seeing intensifying regulatory pressure on energy efficiency. We believe that the recession – which has made “less is more” the watchword of the past few years – is adding to the weight and direction of pressure on public policy. Governments are clearly focused on increasing efficiency and decreasing consumption and costs.

As the following overview of some of the major global markets shows, energy efficiency has become the central plank of governmental energy policy. Moreover, new and emerging regulations will require companies to improve their energy efficiency, creating significant investment opportunities across buildings, industry, IT, power and transport.

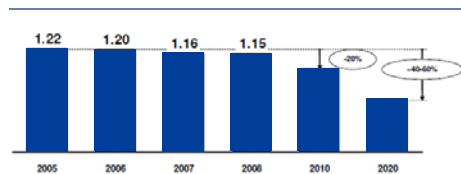
Brazil: 109 TWh of electricity savings by 2030

While Brazil's per capita energy consumption is 28% below the global average, it is higher than the non-OECD average and its total energy consumption has been growing by 3.2%+ in recent years. This is pushing the government to place increasing focus on energy efficiency:

- **The National Climate Change Plan (PNMC (2008))** seeks to increase energy efficiency across various sectors of the economy in line with best practices, and to maintain the high renewable energy mix in Brazil's transport and electricity sectors.
- **The National Energy Efficiency Action Plan** anticipates a reduction in electricity consumption of c.10% by 2030, equivalent to savings of 106 TWh. Focus areas include the replacement of 10 million fridges over 10 years, reducing T&D losses by 1,000 GWh p.a. for 10Y and improving efficiency in buildings, industry and transport.
- **A 36.1-38.9% GHG reduction by 2020** was announced in 2009 with [tackling] deforestation, as well as changes in land and energy use, being the main drivers (source: ABB).

For further research on China's Strategic Priorities, see the work of our China Strategist David Cui.

Chart 30: Chinese government driving energy efficiency (tons of coal eq. / RMB 10 k GDP)



Source: Honeywell, BofA Merrill Lynch Global Research

China, a top national governmental imperative

China started pushing energy efficiency as a top government imperative two years ago, with the topic forming a key plank of the “Long March to Green: 12th Five Year Plan (FYP) of Energy Sector”. The broad aims are:

1. **Achieving a 17.4% energy saving in terms of primary energy consumption per GDP** (ie, increase in coal to power efficiency via technology improvement, and introduction of more efficient generators; changes in the economic structure from fixed capital investment to services, lowering the contribution from high energy-intensive industries; and cutting down exports of high energy-intensive products, such as steel and fertilizers).
2. **Reducing carbon intensity (GHG emissions per unit of GDP) by 17%**
3. **Reflecting the full economic cost of energy consumption.**

Policies, subsidies & bans

In addition to the usual tax and other benefits afforded to high-tech industries, China has plans to undertake the following:

- Five-year phase-out of incandescent light bulbs with a ban on 100w+ bulbs from 1 October 2012, on 60w+ bulbs from 1 October 2014, and on 15w+ bulbs from 1 October 2016. The NDRC also launched the Green Light Project in 1996 to promote energy-saving lighting, and it has subsidized the purchase of 312mn CFLs.
- Invest US\$370bn in the grid from 2011 to 2015, including smart grid on UHV construction and rolling stock.
- Build capacity to produce 500,000 electric vehicles per year.
- Ban sales of low-efficiency motors, and subsidize the purchase of high efficiency motors and high efficiency air conditioners (which use high efficiency motors).
- Subsidize energy management contract (EMC) service providers for energy saved and mandate the use of better heat-proofing materials to cut buildings' energy consumption.
- Launch energy-saving, low-carbon activities at 10,000 high energy-consuming enterprises, an expansion of the existing Top 1000 Enterprises Program.
- Possibly introduce environmental and carbon taxes.

In November 2012, China's President Hu said that it should impose a cap on energy consumption and confirmed the government would impose taxes for resource consumption as well as new fines for companies causing environmental degradation.

Aggressive targets and inflationary pressure

Our bottom-up analysis suggests that the government's 5Y energy-saving target (of 17.4%, vs our 7%) might be too aggressive. Moreover, shifting the energy mix away from coal towards alternatives and reflecting the full economic cost of energy would certainly drive up inflation, at least in the short run.

“The combined effects of full implementation of the existing and new measures will transform our daily life and have the potential to generate financial savings of up to €1,000 per household every year; improve Europe’s industrial competitiveness; create up to 2 million jobs; and reduce annual greenhouse gas emissions by 740 million tons.” (source: EC)

EU: most challenging targets & integrated vision

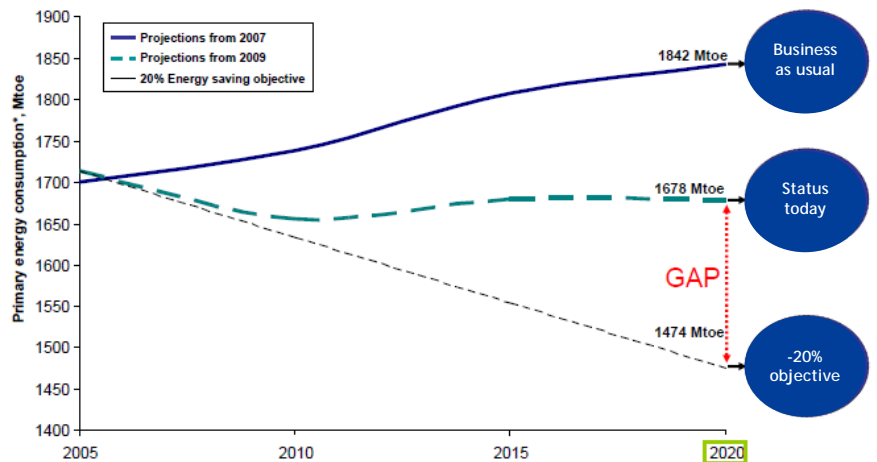
The European Union has set some of the most challenging, integrated approaches to energy policy, climate change and sustainable economic growth, including the 2007 establishment of its 20/20/20 targets, to be met by 2020:

- 20% reduction of GHG emissions by 2020 compared with 1990.
- 20% share of renewable energy in final energy consumption by 2020.
- 20% reduction in EU primary energy consumption by 2020 (vs projected levels), to be achieved by improving energy efficiency.

EC’s Director General (DG) for Energy 60% confident in efficiency target

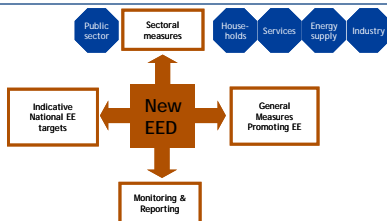
Substantial strides have been made towards achieving the efficiency objective, particularly on appliances and buildings. However, a 2011 impact assessment accompanying the EU’s Energy Roadmap for 2050 has raised doubts about whether the EU will reach its 20% energy efficiency target, with the recession negatively impacting public, commercial and private efficiency investment decisions. The report also highlights "split incentives" or "principal agent market failures", where energy decision-makers are detached from price signals, as an issue. However, the EC’s DG for Energy has said that he is 60% confident that the target will be achieved. A new energy efficiency directive could also act as a driver. The new Energy Efficiency Directive could provide a needed boost.

Chart 31: EU may fall short of its 2020 20% energy saving target



Source: European Commission. *Gross inland consumption minus non-energy uses

Chart 32: Proposed new Energy Efficiency Directive



Source: European Commission

Energy Efficiency Directive (EED) adopted in 2012

In October 2012, the European Council approved an Energy Efficiency Directive requiring energy-savings schemes for utilities, energy audits for all large companies and the renovation of public buildings. Member states have 18 months to transpose this into national law from when it entered into force in November 2012.

- Energy companies will have to achieve a "cumulative end-use energy savings target" by 2020. This target will have to be at least equivalent to achieving savings, each year from 2014 to 2020, of 1.5% of annual energy sales to final customers, by volume, and averaged over the most recent three-year period before the directive takes effect. Sales of energy used in transport will be excluded and alternative ways to achieve equivalent energy savings will be permitted, provided that equivalence was maintained.

- **All large companies will be required to undergo an energy audit.** These audits will need to start within three years of the directive's coming into force and should be carried out every four years by qualified and accredited experts. SMEs are excluded from this obligation.
- **Renovation of 3% of public buildings.** The directive will require member states to renovate 3% of the total floor area of "heated and/or cooled buildings owned and occupied by their central government" (administrative departments whose responsibilities cover the entire territory of a member state). This will apply to buildings with a "total useful floor area" of more than 500 m² and, from July 2015, of more than 250 m². However, member states will also be able to use alternative means to achieve equivalent energy savings (source: European Commission).

2030 targets in sight

The EC is also committed to forging new targets and policies for the EU that will apply from 2020. In March 2013, it published its "2030 framework for climate and energy policies" to consult stakeholders on the framework. Energy Commissioner Günther Oettinger predicts that the proposals could realistically be approved by the EU Parliament and Council in H2 2014. In March 2013, the European Parliament voted in favour of a more stringent post-2020 efficiency target.

India: an imperative for faster, sustainable growth

India faces some of the most significant energy efficiency issues of any of the BRICs, notably from a supply perspective, with transmission losses of c.30%, high levels of energy theft, geographically imbalanced supply and load demand, and basic issues of access, with a majority of rural residents and over 10% of urban residents lacking electricity access. Recent estimates suggest that up to US\$600bn of investment is needed (source: Honeywell). Achieving 9% GDP growth would require energy consumption to grow at around 6.5% p.a., implying a difficult balance between energy dependence and environmental challenges.

Improving policy focus

The approach paper to the 12th five year plan (FY13-FY17) states that: "Increased energy efficiency is the only way to contain energy demand without jeopardizing growth and it must therefore receive high priority". The paper also stresses that "Increasing energy efficiency requires action on two fronts: rationalizing energy prices to incentivize energy efficiency and taking non-price initiatives to push the economy towards greater energy efficiency". Two key developments are:

- Enactment of an Energy Conservation Act, which provides a legal framework for national energy efficiency including the establishment of the Bureau of Energy Efficiency (BEE), which coordinates and implements energy conservation activities.
- Establishment of a National Mission for Enhanced Energy Efficiency as one of eight missions under its National Action Plan on Climate Change. The mission aims to enable Rs 75,000 crore (US\$16.75bn) worth of energy efficiency transactions through policy and financing demand-side management activities and establishing a market-based energy trading initiative. Targets for 2014-15 include: annual fuel savings of at least 23 Mtoe, a cumulative avoided electricity capacity addition of 19,000 MW and a CO₂ emission mitigation of 98 Mt.

For further information see our [India Strategy report on Energy Efficiency](#)

[The IST Report, 09 November 2011](#)

Table 16: NMEEE - Overall estimated investment and expected impact

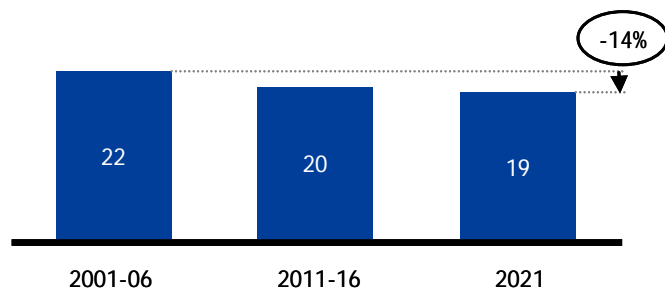
Initiative	Investment Estimated (Rs. crores)	Fuel Saving (Mtoe)	GHG Emissions saving (mt)	Avoided Capacity (MW)
Perform, Achieve and Trade (PAT)	30,603	9.78	26.21	5623
Demand side management	44,000	13.22	72.75	14335
Total	74,603	23	98.96	19,958

Source: BEE

Up to 25% emission intensity reduction by 2020

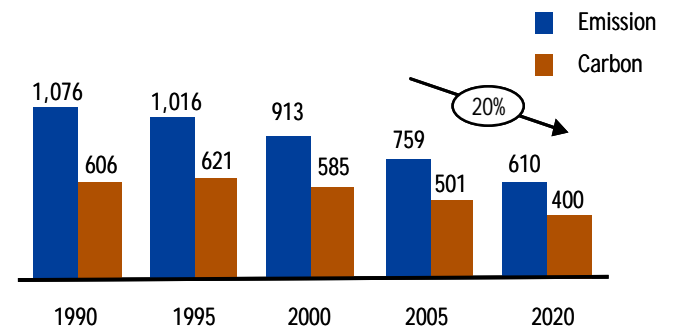
India has set a goal of reducing its emission intensity by 20-25% by 2020 from 2005 levels, with energy efficiency at the core of its strategy. According to P Uma Shankar, the secretary of India's Ministry of Power, India's energy efficiency plans will help to avoid 20GW of additional electricity generation capacity over the next four years and 100 million tons of GHG emissions annually.

Chart 33: National Plan to Improve Energy Efficiency
Kg of Oil Equivalent / Thousand Rs of GDP



Source: Honeywell, BofA Merrill Lynch Global Research

Chart 34: A Trend of Reducing Emission & Carbon Intensity
Tons of CO2 Equivalent / USD Million PPP 2005



Source: Honeywell, BofA Merrill Lynch Global Research

Realising its full energy efficiency potential could save Russia up to US\$80bn annually (source: World Bank)

Russia: 56% reduction in energy intensity by 2030

With per capita energy consumption at 2x the global average, energy intensity 3x higher than for OECD Europe, a high proportion of energy-intensive industry and antiquated industrial stock, Russia is increasingly placing energy efficiency at the heart of its energy strategy (source: ABB, Energy Charter Protocol).

2009-30 Energy Strategy

Russia's Energy Strategy – ES2030, adopted in 2009 – sets a 56% energy intensity reduction target for 2030 (vs 2005 levels). Among the planned measures are a mix of liberalisation; creation of an energy services market; new standards, incentives and penalties; and increasing the energy efficiency of buildings by 40%.

A Federal Law on Energy Conservation and Increase of Energy Efficiency was adopted in November 2009 to create a legal framework for the promotion of energy efficiency – which mainly focuses on buildings, compulsory metering and the establishment of energy passports.

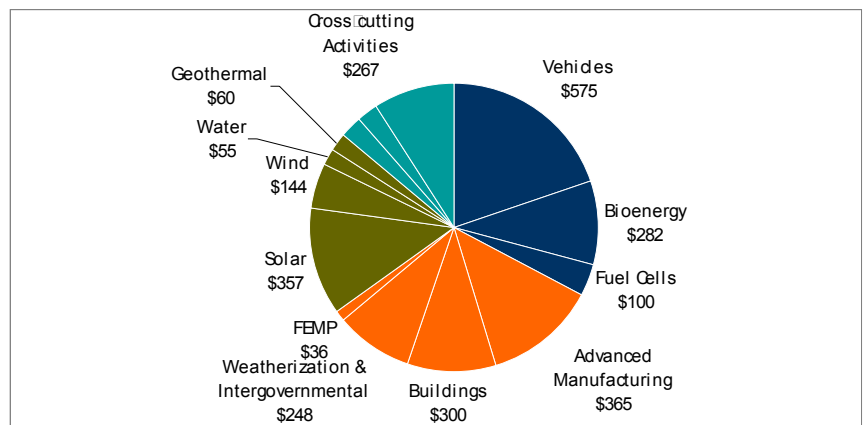
Stakeholders argue that Russia needs to go further

Stakeholders have criticised Russia's measures as being too general, lacking sufficient incentives, and being too top-down (vs at municipal level). They also argue that energy markets have been closed and that little is being done to promote consumer awareness on efficiency. This has seen civil society and companies take a more active role, although it is still early days compared with other markets.

US: efficiency gaining significant momentum

Since 2002-3, the US government has taken increasing measures to improve energy efficiency, including the Global Climate Change Initiative (2002), the Energy Independence and Security Act (2007), the American Recovery and Reinvestment Act (2009), and the National Action Plan for Energy Efficiency (NAPEE), a private-public program, targeting energy savings of 200 TWh by 2025. This comes on the back of increasing recognition that US energy consumption is 60% higher than the OECD average and that primary energy intensity was 20% higher, posing cost and energy security challenges.

Chart 35: US FY 2014 Energy Efficiency & Renewables US\$2.78bn budget request



Source: US DOE, BofA Merrill Lynch Global Research

US\$2.8bn in efficiency at the heart of 2014 budget

Energy efficiency has been one of the President's strategic priorities in recent budgets. The 2014 budget proposal doubles the focus on key energy efficiency programmes, despite the budget axe taking aim at many programmes in both the domestic and defence arenas. The proposed budget requests US\$2.775bn for key energy efficiency programmes in the US Department of Energy (DOE)'s Energy Efficiency and Renewable Energy (EERE) Office.

Table 17: Energy efficiency at the core of US FY2014 budget request (US\$,000)

	FY 2012 Current	FY 2013 Request	FY 2013 Annualized CR	FY 2014 Request
Sustainable Transportation	617,287	770,000	635,573	957,000
Vehicle Technologies	320,966	420,000	330,819	575,000
Bio-energy Technologies	194,995	270,000	200,496	282,000
Hydrogen and Fuel Cell Technologies	101,326	80,000	104,258	100,000
Energy Efficiency	485,289	872,000	495,690	949,000
Advanced Manufacturing	112,692	290,000	116,287	365,000
Building Technologies	214,706	310,000	220,546	300,000
Federal Energy Management Program	29,891	32,000	30,074	36,000
Weatherization and Intergovernmental	128,000	195,000	128,783	248,000
Activities				
Renewable Electricity	471,570	490,000	481,785	615,500
Solar Energy	284,702	310,000	290,719	356,500
Wind Energy	91,813	95,000	93,825	144,000
Geothermal Technologies	36,979	65,000	38,094	60,000
Water Power	58,076	20,000	59,147	55,000
Corporate	216,311	250,000	217,635	267,000
Facilities and Infrastructure	26,311	26,400	26,472	46,000
Program Direction	165,000	164,700	166,010	185,000
Strategic Programs	25,000	58,900	25,153	36,000
Subtotal Energy Efficiency and	1,790,457	2,337,000	1,830,683	2,788,500

Table 17: Energy efficiency at the core of US FY2014 budget request (US\$,000)

	FY 2012 Current	FY 2013 Request	FY 2013 Annualized CR	FY 2014 Request
Renewable Energy				
Use of Prior Year Balances	9,909	69,667	9,970	12,800
Total Energy Efficiency and Renewable Energy	1,780,548	2,267,333	1,820,713	2,775,700

Source: US DOE

DOE putting major focus on efficiency

The US Department of Energy released its inaugural Quadrennial Technology Review report (DOE-QTR) in September 2011, as an initial step towards a government-wide Quadrennial Energy Review to help formulate a national energy policy. The QTR marks a major policy-level move away from technologies that are “multiple generations away from practical use”, towards energy efficiency to provide a more immediate payoff for the US economy and address energy security and competitiveness. It comprises six key strategies:

- Increasing vehicle efficiency
- Electrifying the light duty fleet
- Deploying alternative fuels
- Increasing building and industrial efficiency
- Modernising the electrical grid
- Deploying clean electricity

Table 18: State energy efficiency targets 2012

State	Approx. annual electric savings target	Year of implementation
Arizona	2.30%	2009
Hawaii	2%	2004
Maryland	2.40%	2008
Mass.	1.90%	2009
Minnesot	1.50%	2007
a		
New York	2.10%	2008
RI	2.10%	2006
Vermont	2.20%	2000
Illinois	1.70%	2007
Iowa	1.20%	2009
Colorado	1.40%	2007
Indiana	1.46%	2009
WA	1.30%	2006
Arkansas	0.60%	2010
California	0.90%	2004
Michigan	1.00%	2008
Ohio	1.20%	2008
Oregon	0.98%	2010
New	0.90%	2008
Mexico		
Wisconsin	0.70%	2011
Nevada	0.30%	2005
North	0.50%	2007
Carolina		
Penn.	0.90%	2008
Texas	0.10%	1999

Source: The 2012 State Energy Efficiency Scorecard," American Council for an Energy-Efficient Economy, October 2012

US is catching up with the EU

The EU has long been considered as being far ahead of the US on energy efficiency, but the US EIA projects that structural changes in energy consumption will cut power demand by 33% over the next 30 years. Energy efficiency is projected to cut 13% of power demand over the same period. Given the aggressive demand reduction initiatives at state level (see margin table), we do not see energy efficiency easing with smart meters and more efficient lighting and appliances all having an impact. As at March 2013, state-level progress includes:

- 24 states have EERS (Energy Efficiency Resource Standards) in place
- 40+ states have at least one major utility with financial incentives in place (eg, lost revenue adjustment mechanism, decoupling or performance incentives for gas and/or electric);
- 35+ states have residential and commercial building codes meeting or exceeding 2006/2009/2012 standards; and
- Regional GHG initiative (RGGI) is proposing a 45% reduction in CO2 cap in 2014, with additional annual reductions of 2.5% from 2015-2020 (source: ACEE Energy Efficiency 2013 Outlook)

Table 19: US energy efficiency progress vs EU 2000-2010

Overview	2010	2000-2010 (%/year)	
Primary intensity (EU = 100) ¹	140 --	-2.0%	+
CO2 intensity (EU - 100)	159 --	-2.0%	+
CO emissions per capita (in tCO2/cap)	17 --	-1.0%	+
Power generation	2010	2000-2010 (%/year)	
Efficiency of thermal power plants (in %)	39 +	1.0%	+
Rate of electricity T&D losses (in %)	6 +	0.3%	--
CO2 emission per kWh generated (in gCO2/kWh)	510 --	-1.0%	+
Industry	2010	2000-2010 (%/year)	
Energy intensity (EU = 100)	156 --	-2.0%	+
Share of industrial CHP in industry consumption (in %)	18 -	1.0%	-
Unit consumption of steel (in toe/t)	0.4 -	0.4%	-

Source: ABB, BofA Merrill Lynch Global Research

++ Among best countries + Better than the EU average¹ - Below the EU average¹ --Among countries with the lowest performances

Table 20: BofAML Auto & Energy Efficiency Stock List

Company	EE exposure
BORGWARNER INC	High
FLEETMATICS	High
INFINEON	High
LINEAR TECHNOLOGY	High
MAHLE METAL LEVE	High
SANKEN ELECTRIC	High
SENSATA	High
TESLA MOTORS INC	High
VALEO SA	High
MAHLE METAL LEVE	High
SENSATA	High
AUTOMETAL	Medium
CONTINENTAL AG	Medium
DELPHI AUTOMOTIVE	Medium
HONEYWELL	Medium
JOHNSON CONTROLS INC	Medium
MAGNA INTERNATIONAL	Medium
MICHELIN (CGDE)-B	Medium
TENNECO INC	Medium
AQUARIUS PLATINUM	Low
JOHNSON MATTHEY PLC	Low
LANXESS	Low
LKQ CORP	Low
SOLVAY	Low
TORAY INDUSTRIES INC	Low
VICTREX	Low

Source: BofA Merrill Lynch Global Research. * EE exposure = BofAML estimates of energy efficiency exposure.

Auto, green “transficiency” evolution

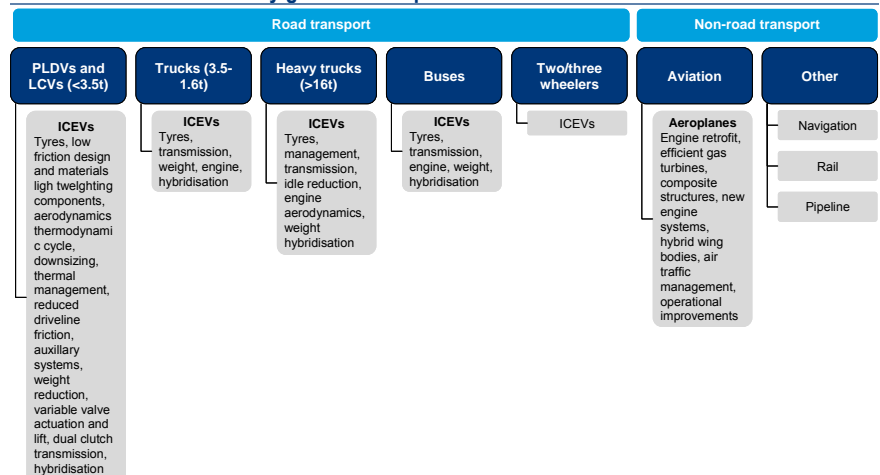
Globally, road transport-related CO2 emissions represented almost 17% of the total CO2 emissions from fuel combustion in 2009 according to the IEA.

Road transport was thus the third highest source of CO2 emissions from fuel combustion. Within road transport, automobiles and light trucks produce well over 60% of emissions (Source: IEA). With non-OECD and emerging market car sales set to exceed those in the OECD by 2020, and the global passenger car fleet set to double to reach almost 1.7bn by 2035, the auto sector is coming under growing pressure on oil consumption, energy security and CO2 emissions. With limited near-term scope for oil substitution in transport – and a robust increase in oil demand expected for the next five years – we think the sector will need to make significant gains on fuel economy via efficiency gains and upgrading the fleet.

We believe that ultimate path towards automotive fuel efficiency will be more of an evolution than a revolution. It could involve a three stage transition including: 1) leveraging technology to improve the efficiency of the internal combustion engine and light weighting of the vehicle; 2) increasing use of hybrid and hybrid electric powertrains; and 3) exogenous technology shock. Growing fuel efficiency regulation around the world is placing an increasingly significant R&D burden on all auto OEMs, but we do not believe that regulation alone will be a driver of material changes. We anticipate the evolution will be market driven as consumers demand more fuel efficient vehicles to ultimately reduce personal expenditure on fuel.

We believe that a number of stocks are well placed to benefit from the theme of energy and fuel efficiency in the auto sector through their involvement in areas such as autocatalysts, diesel, electric vehicles (EVs), engine and transmission components, gasoline direct injection (GDI), light-weighting, li-ion batteries, natural gas, specialty polymers, turbochargers, tyres and fleet management, among other areas.

Chart 36: Potential efficiency gains in transport



Source: IEA WEO Outlook 2012, BofA Merrill Lynch Global Research

Cross Reference - Global Automotive Supplier Review's "The Path Towards Fuel Efficiency"

A comprehensive overview of the efficiency and fuel economy issues raised in this section can be found in our Global Auto team's "Who Makes the Car" report [Global Automotive Supplier Review, 17 April 2013](#)

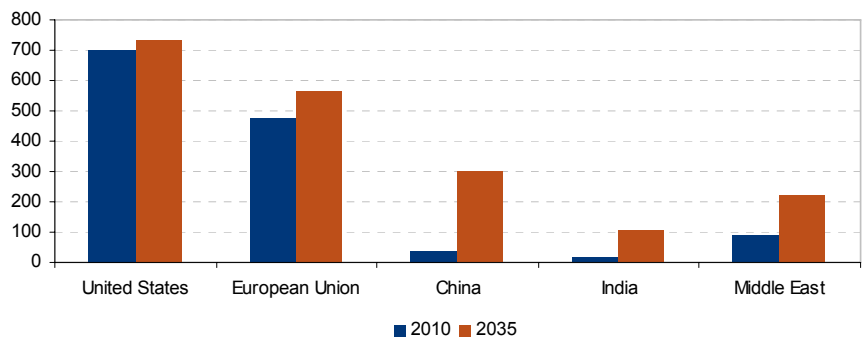
Road transport, #3 source of fuel combustion-related emissions

#3 source of fuel combustion-related emissions

Transport – including road, air and maritime – accounts for about 19% of global energy use and 23% of global energy-related CO2 emissions. Road transport-related CO2 emissions represented almost 17% of the total CO2 emissions from fuel combustion in 2009 according to the IEA. Road transport was thus the third-highest source of CO2 emissions from fuel combustion after "electricity and heat production" and "manufacturing industries and construction".

With non-OECD and emerging market car sales set to exceed those in the OECD by 2020, and the global passenger car fleet set to double to reach almost 1.7bn by 2035, the auto sector is coming under growing pressure on oil consumption, energy security and CO2 emissions – and in terms of making gains on fuel economy via efficiency gains.

Chart 37: Vehicles per 1000 people in selected markets 2010-35

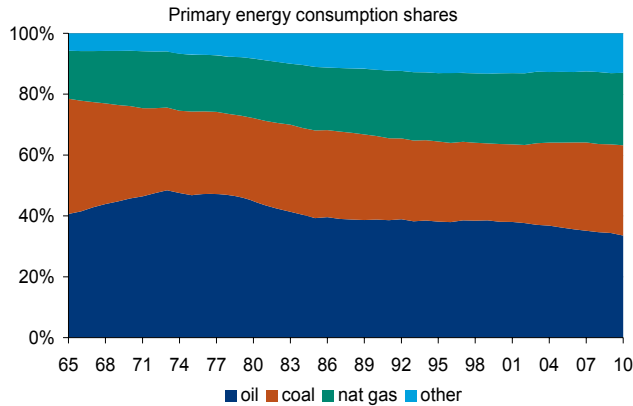


Source: IEA WEO 2011, BofA Merrill Lynch Global Research

Substitution is tough in the transportation sector

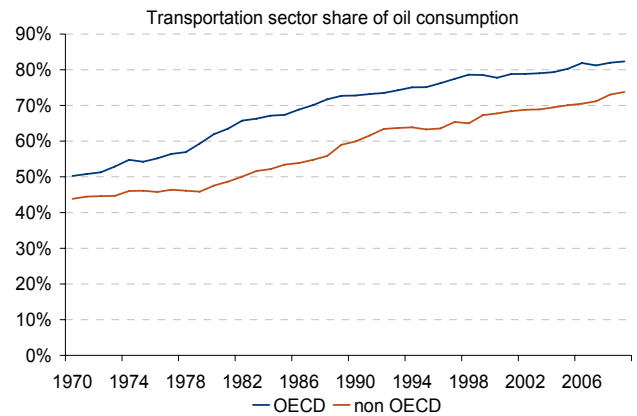
Oil today is primarily a transportation fuel. As we outline below, even if the technology were to allow for substitution out of oil in transportation, via natural gas-powered vehicles or plug-in hybrid vehicles, there is limited scope for large-scale substitution unless energy policies set the right incentives and until the necessary infrastructure and distribution systems are developed. Thus, oil efficiency improvements will hinge primarily in the near term on fuel efficiency advancements in transportation and upgrading of the fleet.

Chart 38: The aftermath of the oil crisis of the 70s and 80s saw large-scale substitution out of oil into other and cheaper thermal fuels



Source: IEA, BofA Merrill Lynch Global Research

Chart 39: Oil is today primarily a transportation fuel



Source: IEA, BofA Merrill Lynch Global Research

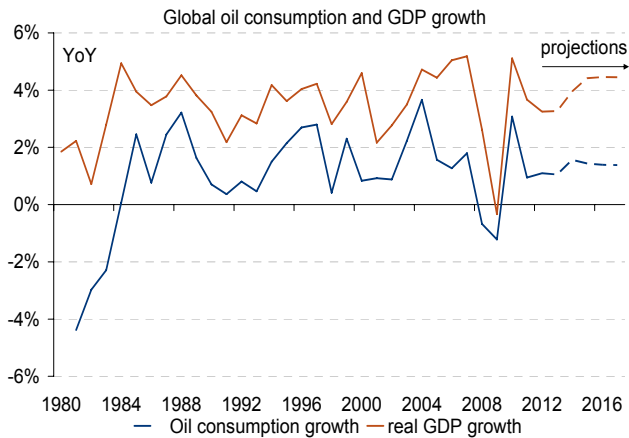
Cross Reference - Global Commodities' "Medium-term oil outlook"

[Global Energy Paper, 18 February 2013](#)

Robust increase in oil demand likely in the next five years

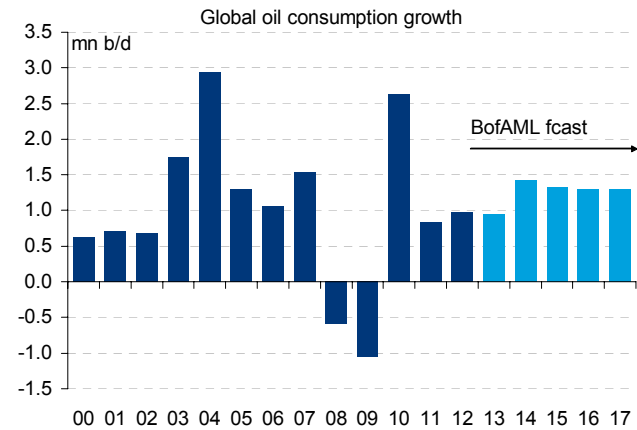
On our Global Commodities Research team's estimates, from 2014 to 2017, global activity is set to expand at a rate of 4-4.5%. This acceleration in global GDP growth is set to boost oil demand growth significantly given the high beta of oil consumption relative to GDP. We expect global oil demand growth of 1.3m b/d, on average, between 2014 and 2017, up from 940m b/d in 2013. Global oil demand is thus poised to increase from 89.8m b/d in 2012 to 96.1m b/d in 2017.

Chart 40: Global economic activity is set to rebound strongly in 2014E after subdued real GDP growth of 3.3% in 2013E



Source: IEA, IMF, BofA Merrill Lynch Global Commodity Research

Chart 41: We expect global oil demand growth of 1.3m b/d, on average, in 2014-17, up from 940m b/d in 2013E



Source: IEA, BofA Merrill Lynch Global Commodity Research

US oil demand shrinks on efficiency improvements

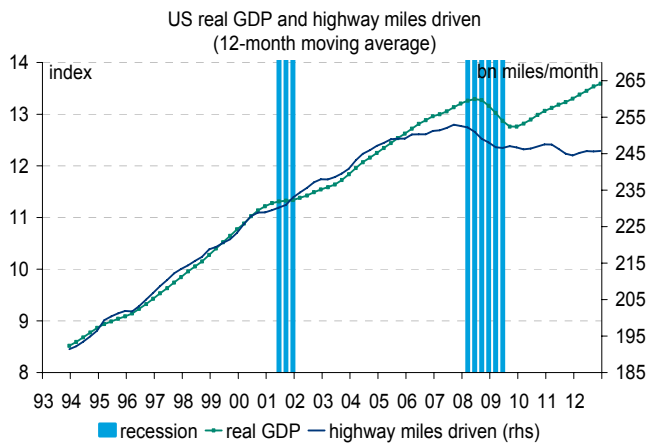
Demand for oil in the United States peaked in 2005 and has fallen by 2.3m b/d since then, in part driven by the economic recession. In our view, the trend of falling oil consumption in transportation is poised to continue as the US's economy becomes more energy and fuel efficient. Net, we expect US oil consumption to decline by an average of 60k b/d per year over the next five years.

The CAFE standards mandate a steady increase in average MPGs of new car sales until 2016. Originally they covered only cars and light duty trucks but since 2012 they also apply to medium-duty trucks and from 2014 to heavy duty trucks.

US gasoline demand is contracting on increased efficiency...

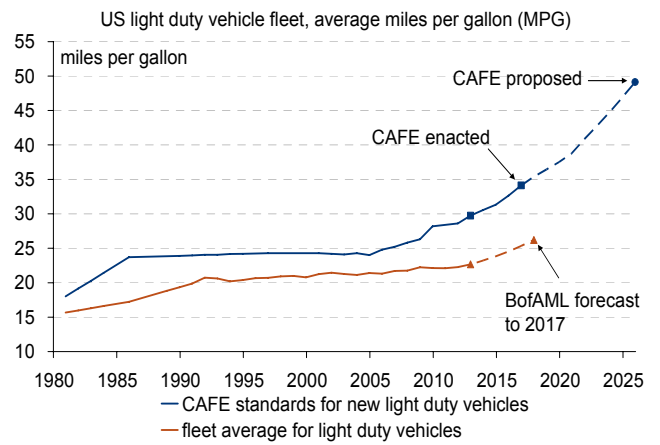
Since the onset of the recession, highway miles driven in the United States have contracted sharply, in part driven by the negative impact of the recession and slow employment growth. In addition, negative demographic factors resulting from a retiring 'baby boomer' generation also explain why miles driven have decoupled from GDP growth. With the US economy expected to rebound strongly later this year, miles driven will likely pick up again. Over the medium term, the two major determinants of gasoline consumption in the US are (1) highway miles driven, and (2) changes in the average vehicle fuel efficiency (miles per gallon). In our view, strong fleet fuel efficiency improvements should, however, more than offset any increase in miles driven, as fleet replacement rates and Corporate Average Fuel Efficiency (CAFE) standards increase materially to 2017 (Chart 42).

Chart 42: Since early 2000s, growth in miles driven has fallen short of GDP growth



Source: EIA, Bloomberg, BofA Merrill Lynch Global Commodity Research

Chart 43: We expect fleet replacement rates and Corporate Average Fuel Efficiency standards to increase materially to 2017

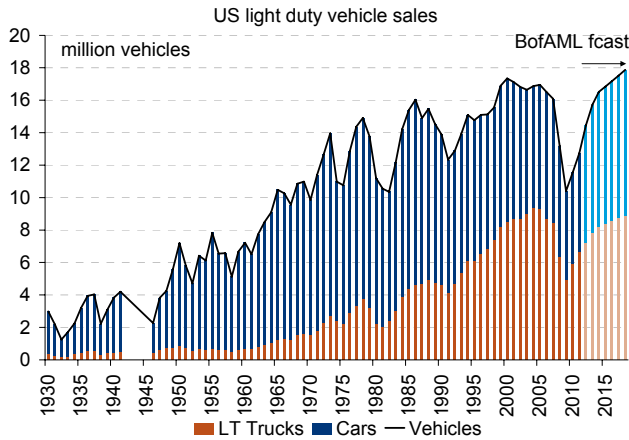


Source: EIA, Bloomberg, BofA Merrill Lynch Global Commodity Research

...with efficiency improvements set to accelerate...

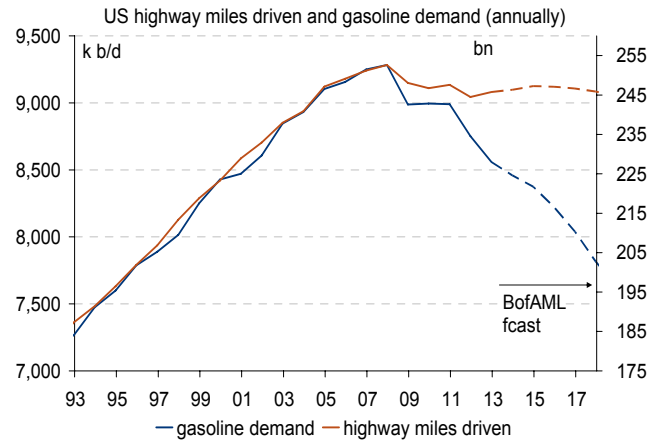
As the cyclical improvement in miles driven wears off in 2014, fuel efficiency improvements will become an even more dominant driver of gasoline consumption, in our view. Due to the 2008/09 recession and an extended period of depressed consumer confidence, US vehicle sales have been running below their historical median for a few years now. Thus, the fleet has been getting older and many vehicles are due for replacement. Light vehicle sales started to pick up in 2012 and will likely continue to increase at a strong rate out to 2017. Compared to an average annual growth of 12.5m during 2008-12, we expect light vehicle sales to average 16.8m vehicles in 2013-17. Partly in anticipation of this, manufacturers are launching a near record number of new light vehicle models this year. Faster replacement of the vehicle fleet will likely increase the average fuel efficiency of the entire fleet. The combination of strong vehicle sales, an increasing preference for smaller cars over larger ones and rising fuel efficiency standards should lead to strong contractions in US gasoline demand over the medium term. We expect US gasoline consumption to contract by 750k b/d from 2012 to 2017.

Chart 44: Our colleagues in equity research think light vehicle sales will pick up and likely peak in 2017-18



Source: Bloomberg, JD Power, BofA Merrill Lynch Global Research

Chart 45: We expect US gasoline consumption to contract by 750k b/d from 2012 to 2017

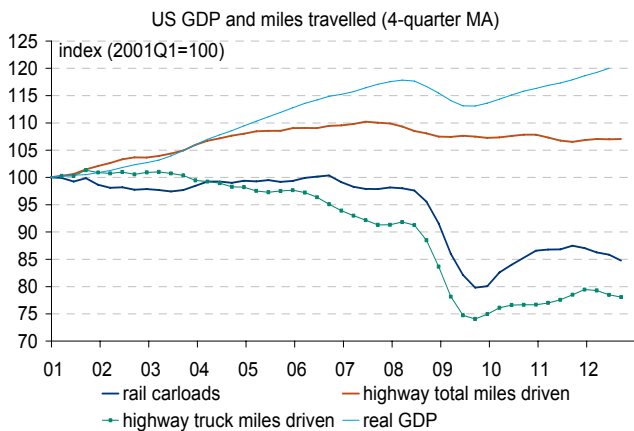


Source: EIA, ICCT, Bloomberg, BofA Merrill Lynch Global Commodity Research

...and a structural shift in on-road diesel use by trucks

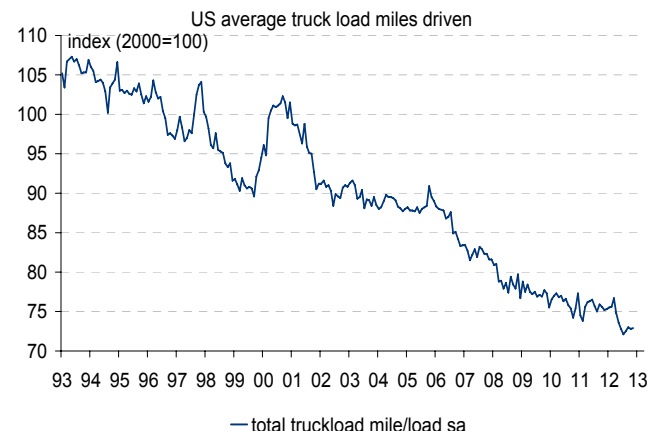
A drop in long haul trucking activity since 2000 has been exacerbated by a switch to rail, due to high fuel and labour costs as well as structural changes in the US economy (Chart 45). Since trucking volumes peaked in 2000, tonne mile activity in large trucks has declined by 23%, most severely during the 2008/09 recession. Moreover, since China entered the World Trade Organisation (WTO) in 2001, the US has increasingly imported manufactured goods rather than producing them domestically, and the average cross-country movement of goods has declined. However, we expect this trend to moderate somewhat, as partly much substitution to rail in long haul trucking has already taken place after years of high oil prices and partly as the US economy benefits from a domestic manufacturing renaissance. Consequently, we expect diesel consumption in the US to grow modestly over the next five years out to 2017 (cumulatively +80k b/d).

Chart 46: The drop in long haul trucking activity since 2000 has been exacerbated by a switch to rail



Source: Bloomberg, BofA Merrill Lynch Global Commodity Research

Chart 47: Miles per truck load have declined on structural substitution for more than two decades now



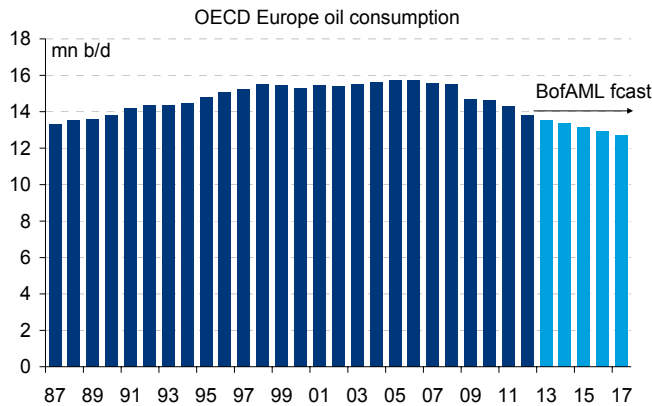
Source: Bloomberg, BofA Merrill Lynch Global Commodity Research

European oil demand set to continue to fall structurally...

On the other hand, oil demand in Europe has been falling structurally since 2006 due to a major policy push to improve efficiency. In recent years, however, distillate demand (used in over 60% of the continent's cars) has fallen sharply on

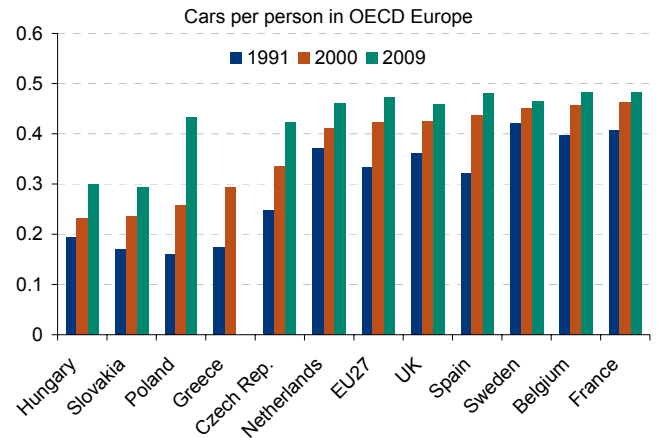
the back of the ongoing double-dip recession (Chart 48). With vehicle penetration in Europe among the highest in the world combined with an aging population, the average fuel efficiency of the fleet should continue to increase. Structurally, Europe faces some of the world's worst demographic challenges with an aging population, which affects labour participation and reduces driving (Chart 48). Having said that, we think the decline in European oil demand in 2014E will be slightly lower than in other years, as the cyclical recovery from the recession brings about an increase in driving activity.

Chart 48: Oil demand in Europe is falling structurally due to efficiency, substitution and, of course, low economic growth



Source: IEA, BofA Merrill Lynch Global Commodity Research

Chart 49: Vehicle penetration in Europe is among the world's highest, limiting demand growth

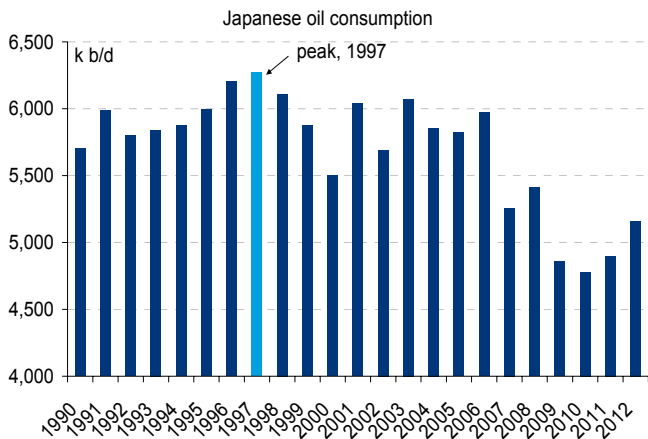


Source: Eurostat, BofA Merrill Lynch Global Commodity Research

...while Asia Pacific OECD demand will likely fall

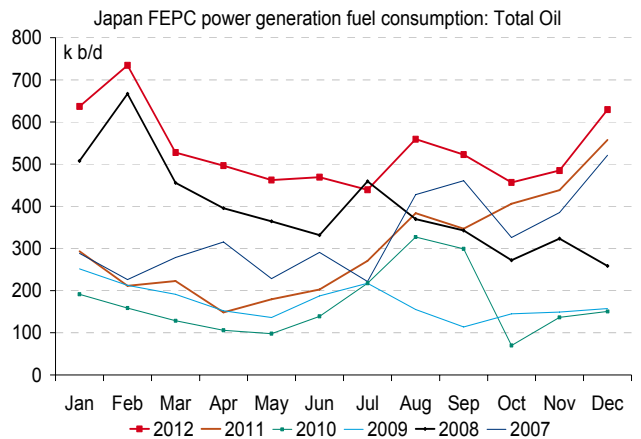
With rising life expectancy, very low birth rates and a huge baby boomer generation entering retirement age, the share of the population under the official retirement age of 55 continues to fall sharply in Japan. In fact, Japanese oil demand peaked in the late 1990s, much earlier than in other OECD countries. Though the overall long-term trend in Japanese oil consumption is down given demographics, the nuclear power generation shutdown on the back of the Fukushima disaster has been driving up oil demand in the past few quarters.

Chart 50: The population of under 55s started contracting in 1980, and oil demand peaked in the late 1990s



Source: IEA, BofA Merrill Lynch Global Commodity Research

Chart 51: Power generation has supported oil demand in Japan in the past few quarters

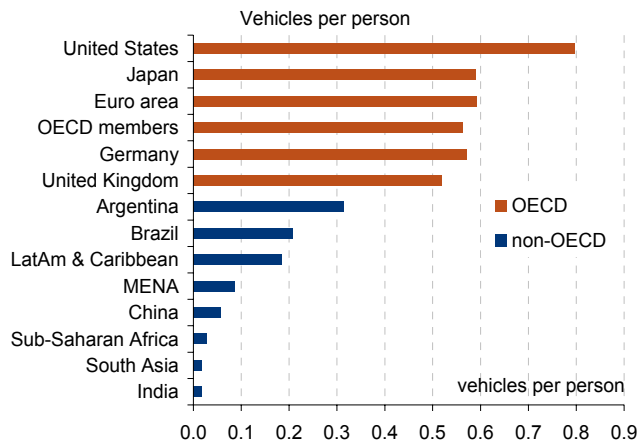


Source: FEPC, BofA Merrill Lynch Global Commodity Research

Meanwhile, oil consumption in EMs is set to increase sharply

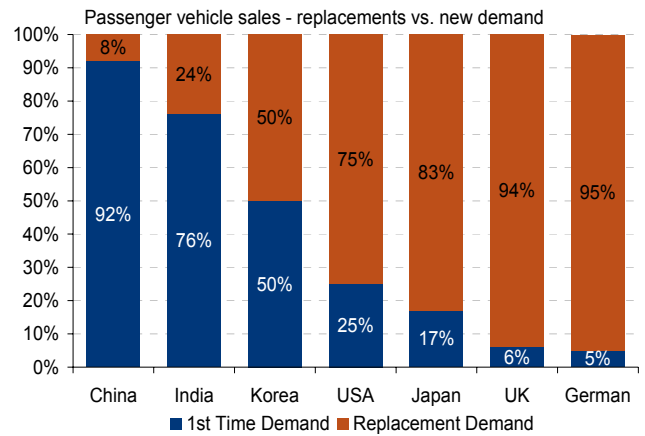
Despite the muted growth picture in advanced nations, vehicle sales in EMs have continued to increase sharply in recent years. Even so, countries like China still have very low passenger car per capita ratios compared with advanced nations like the US, Germany or Japan, which implies huge potential for growth in their car fleet. This is also true for other heavily populated EMs, such as India and Indonesia. In contrast to advanced nations, most new car sales contribute to fleet growth rather than replacement vehicles. Hence, the increase in sales in EMs is strongly associated with growth in oil consumption. It is worth noting that car proliferation in the US and Japan started after World War II, while China, India and other EMs are only just getting started.

Chart 52: With one of the world's largest populations and lowest vehicle per capita ratios, we see huge growth potential in China's fleet



Source: World Bank, BofA Merrill Lynch Global Commodity Research

Chart 53: In many emerging economies, most new car sales contribute to fleet growth rather than replacements

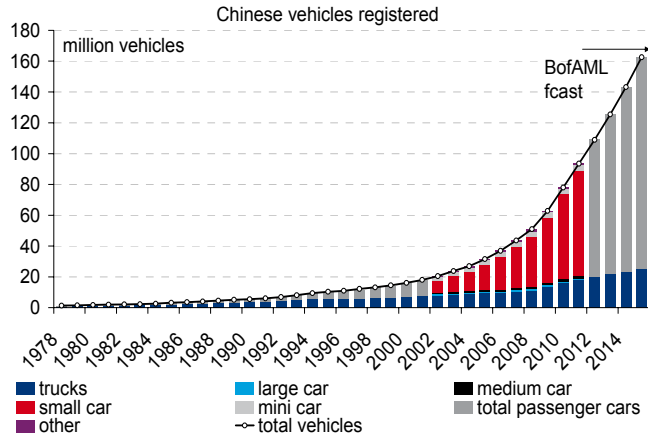


Source: BofA Merrill Lynch Global Research

We foresee strong growth in cars and trucks in China

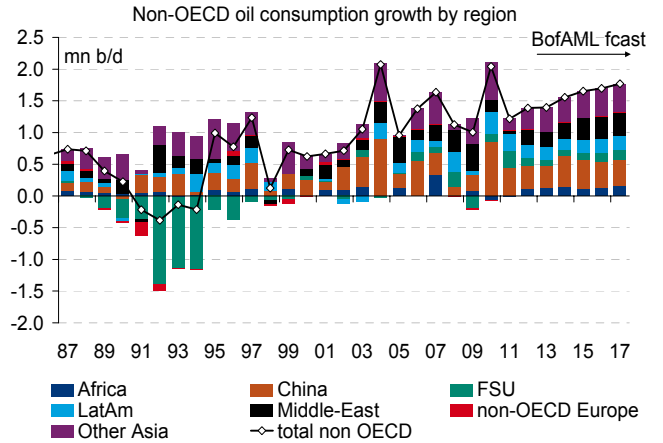
In contrast to the trends in developed markets, Chinese cars are getting bigger and more fuel intensive. Sales growth is particularly strong in the heavier light duty vehicle segments, such as SUVs, which implies that the average fuel efficiency is not really improving. Our China automotives analyst Bin Wang believes there is limited scope for diesel in Chinese passenger cars as the scarce supply is mostly geared towards agricultural and heavy trucking machinery. With little or no improvements in the average car fuel efficiency due to growing preferences for larger cars, and a car fleet that is expanding at a constant to slightly increasing rate each year, oil consumption in China is still structurally rising at a high and steady rate each year over the medium term. We see average annual oil demand growth of about 0.42m b/d YoY to 2017.

Chart 54: In contrast to the trends in developed markets, Chinese cars are getting bigger and more fuel intensive



Source: JD Power, BofA Merrill Lynch Global Research
Note: 2013-14 represent BofAML forecasts, 2014+ are projections from JD Power.

Chart 55: We see oil demand growth of about 0.42m b/d YoY in each year from 2015 to 2017

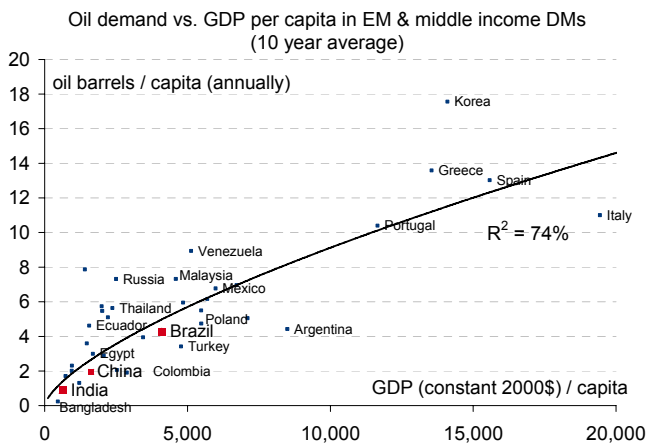


Source: IEA, BofA Merrill Lynch Global Commodity Research

Non-OECD set to overtake OECD

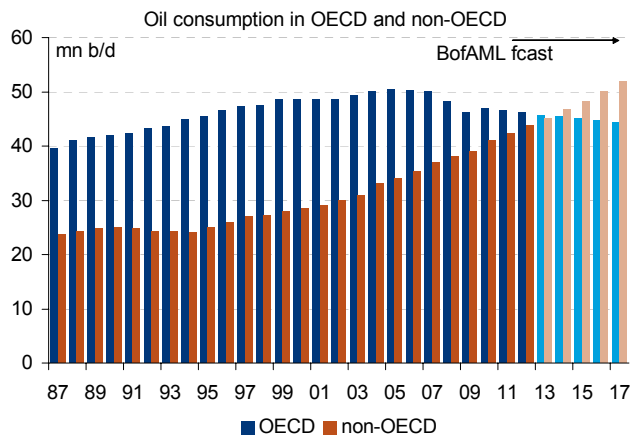
The economic benefits of globalization, urbanization and industrialization have led to major productivity gains in Emerging Markets and oil consumption per capita has increased as a result. In fact, the non-OECD block is set to increase its consumption of oil products to 46.80m b/d by 2014, compared to 33m b/d 10 years ago. By 2014, non-OECD countries are set to overtake OECD countries in terms of how much oil they consume. By region, we forecast that non-OECD Asia (incl. China) and the Middle East will provide the bulk of growth to 2017 (4.2m b/d and 1.6m b/d, respectively).

Chart 56: Major productivity gains in EMs due to globalisation and urbanisation have led to big increases in oil consumption per capita



Source: IEA, BP, WB, IM,F, BofA Merrill Lynch Global Commodity Research

Chart 57: By 2014, non-OECD countries are set to overtake the OECD countries in terms of how much oil they swallow



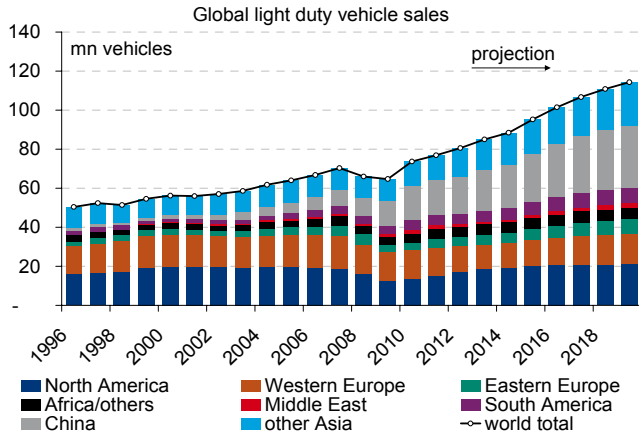
Source: IEA, BofA Merrill Lynch Global Commodity Research

Global car sales are set to grow strongly to 2020

Despite a surge in fuel-efficient vehicle sales in the developed world, global population in the prime driving age band (15-65) continues to grow strongly, as do global car sales. With a rising number of drivers and higher incomes in EMs, demand for cars and oil consumption around the world is set to increase substantially over the medium term. In contrast, the shrinking prime driving age population in DMs is set to accelerate the ongoing oil demand contraction in

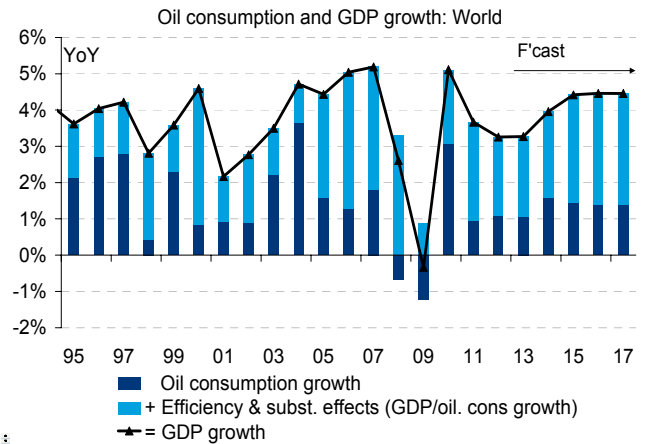
OECD nations. Overall, we expect global oil demand to grow by 6.3m b/d to 2017 as we recover from weak global GDP growth (Chart 58).

Chart 58: We see car sales growing as a rising population of potential drivers with growing income demand more cars



Source: JD Power, BofA Merrill Lynch Global Commodity Research

Chart 59: Overall global oil consumption is expected to grow by 6.3m b/d to 2017

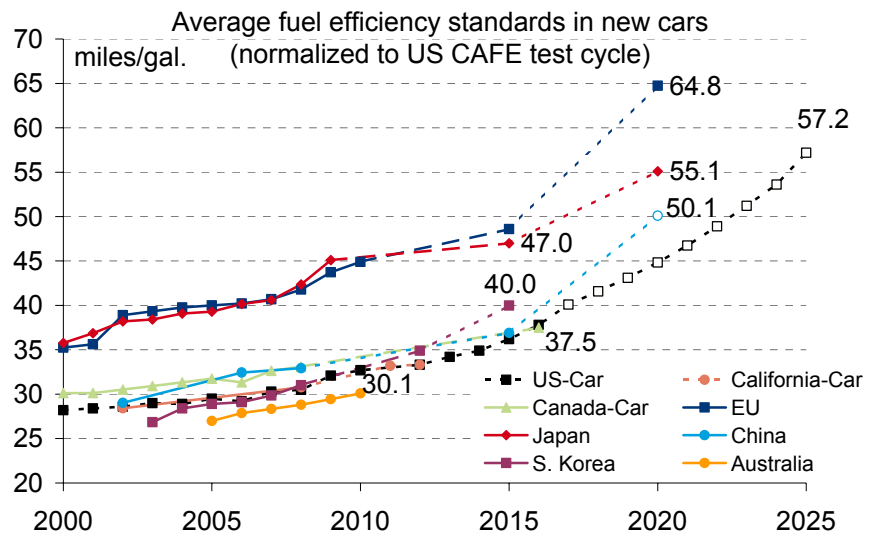


Source: IEA, BofA Merrill Lynch Global Commodity Research

Regulation alone will not drive material change

Increasingly stringent global fuel economy and CO2 emission regulations are requiring automakers to remain focused on improving their fuel economy. This is simultaneously becoming a slightly greater focus area for consumers.

Chart 60: Targets for improvements in fuel efficiency standards of new cars in the US by 2016 are among least ambitious in the OECD



Source: ICCT, BofA Merrill Lynch Global Research

Solid dots and lines represent historical performance; Solid dots and dashed lines: enacted targets; Solid dots and dotted lines: proposed targets; Hollow dots and dotted lines: unannounced proposal

Existing technologies vs. EVs

While the shift to these new standards is arguably more aggressive than transitions implemented in the past, and will likely result in additional cost to the industry, we continue to believe that regulation alone will not drive a material

move towards all-electric vehicles. Instead, we expect existing technologies geared towards making traditional internal combustion engines more fuel efficient to gain greater acceptance over the near term in the first stage of the evolutionary process.

Table 21: Global comparison of fuel economy/GHG standards

Country or Region	Target Year	Standard Type	Unadjusted Fleet Target/Measure	Structure	Targeted Fleet	Test Cycle
U.S./California (enacted)	2016	Fuel Economy/GHG	34.1 mpg* or 250 gCO2/mi	FP-based corporate average	Cars/Light Truck	U.S. Combined
U.S. (Supplemental notice of Intent)	2025	Fuel Economy/GHG	49.6 mpg* or 163 gCO2/mi	FP-based corporate average	Cars/Light Truck	U.S. Combined
Canada (enacted)	2016	GHG	153 (141)*** gCO2/km	FP-based corporate average	Cars/Light Truck	U.S. Combined
EU (enacted)	2015	CO2	130 gCO2	Wt.-based Corp. average	Cars/SUVs	NEDC
EU (proposed)	2020	CO2	95 gCO2/KM	Wt.-based Corp. average	Cars/SUVs	NEDC
Australia (voluntary)	2010	CO2	222 gCO2/km	Fleet average	Cars/SUVs/Light CV	NEDC
Japan (enacted)	2015	Fuel Economy	16.8 km/L	Wt.-class based Corp. average	Cars	JC08
Japan (proposed)	2020	Fuel Economy	20.3 km/L	Wt.-class based Corp. average	Cars	JC08
China (proposed)	2015	Fuel Consumption	7 L/100km	Wt. based/vehicle & Corp. average	Cars/SUVs	NEDC
China (under study)	2020	Fuel Consumption	5 L/100km	Wt. based/vehicle & Corp. average	Cars/SUVs	NEDC
South Korea (proposed)	2015	CO2	17 km/L or 140 gCO2/km	Wt.-based Corp. average	Cars/SUVs	U.S. Combined
India (under study)	2015	CO2	136 g/km	Wt.-based Corp. average	Cars/SUVs	NEDC
India (under study)	2020	CO2	121 g/km	Wt.-based Corp. average	Cars/SUVs	NEDC

Source: The International Council on Green Transportation

* Assumes manufacturers fully use A/C credit

*** Proposed CAFE standard by NHTSA. It is equivalent to 163g/mi plus CO2 credits for using low-GWP A/C refrigerants

Most challenging regulations in Europe

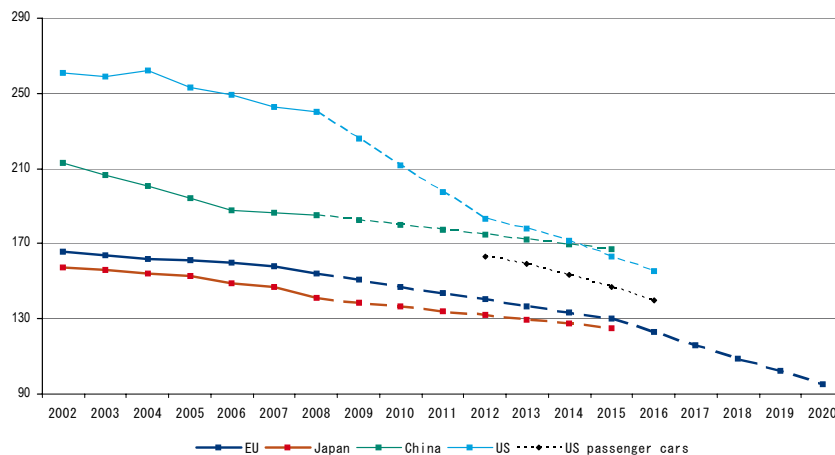
Road transport contributes 18% of the EU's total CO2 emissions and its emission levels have been rising faster than in other sectors since 1990. This has seen the European Commission taken a pioneering role among global regulators in regulating CO2 emissions, with a 2015 target of 130gCO2/km by 2015 and 95gCO2/km by 2020.

130 gCO₂/km for OEMs by 2015

In December 2008 the European Parliament and Council set new rules on CO2 emissions for OEMs whereby the average CO2 emissions of each car manufacturer's sold fleet in Europe must be below 130gCO2/km by 2015. An additional reduction of 10gCO2/km is targeted to be derived from complementary measures, including greater use of biofuels and via tyres. As these measures are not primarily driven by the car producers, their primary target generally stands at 130gCO2/km.

At the end of 2009, the average emissions amounted to 145.9gCO2/km (2007: 158.7gCO2/km). There are also intermediate requirements that need to be fulfilled: 65% of new cars have to comply with the requirements in 2012; 75% in 2013; 80% in 2014; and 100% in 2015. Increasing penalties, from €5 to €95 for each g/km exceeded, have been established (€5 for the 1st additional gram, up to €95 for the 4th additional gCO2/ km and more).

Chart 61: CO2 emission by geography



Source: ICCT, NHTSA, ML

There is a different provision for niche manufacturers like Porsche, with 10,000-300,000 cars per year. As it would be practically impossible for some of these producers to meet the 130gCO₂/km target, there is a simple regulation calling for a 25% reduction of 2007 emission levels until 2016.

Individual targets may vary depending on weight

The general requirement of 130gCO₂/km could actually be slightly higher, depending on the weight of the cars. This means that the requirement for heavier cars is slightly loosened. For example, Daimler needs to achieve 138gCO₂/km (instead of the general 130gCO₂/km) by 2015. However, from 2014 weight increases in new cars will be studied to avoid cars getting heavier simply to secure larger CO₂ allowances.

Incentives through Super-credits and Penalties

Super-credits will be assigned to vehicles emitting less than 50gCO₂/km. In 2012, such a car will count as 3.5 cars when it comes to calculating the average fleet emission, thus it is a clear incentive. The super-credits will be phased out by 2016, at which point these cars will have a normal weighting of one.

On the flipside to this incentive, the imposed penalties pose an expensive threat in the event of non-compliance. The penalty amounts to €95 for each gram in excess of the target. Small deviations from the requirement will be penalized on a lesser scale, with €5-25 per gram for 1-3gCO₂/km.

OEMs on track to meet targets

To date, according to data from the EU, OEMs are on track to meet the 2015 targets – with average CO₂ emissions from new passenger cars registered in the EU27 in 2009 at 145.7 gCO₂/km, and 65% of new passenger cars registered in 2009 already below 130 gCO₂/km.

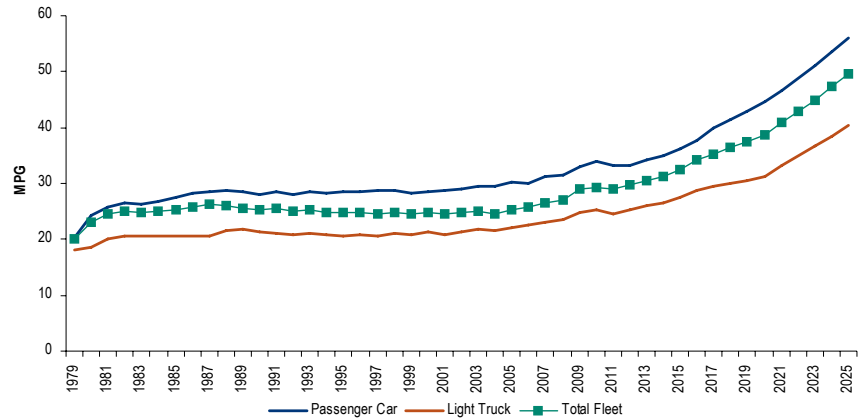
95g/km by 2020

The long-term goal is to reduce CO₂ emissions to 95gCO₂/km by 2020. The modalities of reaching this target are to be defined no later than the beginning of 2020

And finally some progress in the US

Standards for fuel economy in the US have remained fairly steady in both the passenger car and light truck categories over the past decade. In fact, prior to recent regulation that will phase in over the next few years, it appears only modest progress has been made since the early 1980s. Over this time the industry has made progress on engine and transmission technology, but the benefits have gone to increased performance as opposed to fuel efficiency.

Chart 62: CAFE Standards



Source: NHTSA

Historical fuel efficiency standards

The table below outlines the National Highway Traffic Safety Administration's (NHTSA) fuel economy standards for the US light vehicle market in more detail, which will ultimately require average US fuel economy of 34.1mpg by 2016 and 49.6 by 2025.

Table 22: Average Required Fuel Economy (mpg) under CAFE Standards

Vehicle Type	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Passenger Car	33.3	34.2	34.9	36.2	37.8	40.0	41.4	43.0	44.7	46.6	48.8	51.0	53.5	56.0
Light Truck	25.4	26.0	26.6	27.5	28.8	29.4	30.0	30.6	31.2	33.3	34.9	36.6	38.5	40.3
Total Fleet	29.7	30.5	31.3	32.6	34.1	35.3	36.4	37.5	38.8	40.9	42.9	45.0	47.3	49.6

Source: NHTSA

"These fuel standards represent the single most important step we've ever taken to reduce our dependence on foreign oil" - US President Obama

The 2012 ruling was unique in that NHTSA worked jointly with the Environmental Protection Agency (EPA) to broaden the scope of regulation to include CO2 standards, which effectively increases the implicit fuel economy targets.

In our view, NHTSA's most recent ruling (finalized in August 2012) was unique in that the group worked jointly with the Environmental Protection Agency (EPA) to broaden the scope of regulation. As a result, the new US fuel economy standards now include CO2 emission limitations, which effectively increase the implicit fuel economy targets. For instance, the 34.1 mpg target for 2016 is actually increased to 35.5 mpg as CO2 emission reductions from 295 g/mi in 2012 to 250 g/mi in 2016 are enforced, while the 49.6 mpg target for 2025 becomes 54.5mpg.

Table 23: EPA rules and their effect on mpg if NHTSA targets also reached

Vehicle Type	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Passenger Cars (g/mi)	263	256	247	236	225	212	202	191	182	172	164	157	150	143
Light Trucks (g/mi)	346	337	326	312	298	295	285	277	269	249	237	225	214	203
Agg. Car/Truck (g/mi)	295	286	276	263	250	243	232	222	213	199	190	180	171	163
Agg. Car/Truck (mpg)	30.1	31.1	32.2	33.8	35.5	36.6	38.3	40.0	41.7	44.7	46.8	49.4	52.0	54.5

Source: EPA; NHTSA

This new ruling is viewed as being very important given the US Department of Energy's estimate that 51% of a typical US household's CO2 emissions are attributable to vehicles.

This new ruling is viewed as being very important given the US Department of Energy's estimate that 51% of a typical US household's CO2 emissions are attributable to vehicles.

Chart 63: Sources of CO2 Emissions for a Typical Household



Source: US Department of Energy

The U.S. federal government estimates that the national program to improve fuel economy and reduce greenhouse gas emissions will save consumers more than \$1.7tn at the gas pump and reduce U.S. oil consumption by 12bn barrels.

Table 24: MY 2025 CO2 and Fuel Economy Targets for Representative MY 2012 Vehicles

Vehicle type	Model footprint (sq. ft.)	EPA CO2 emissions target (g/mi)*	NHTSA fuel economy target (mpg) */**
Compact car	40	131	61.1
Mid-size car	46	147	54.9
Full-size car	53	170	48.0
Small SUV	43	170	47.5
Mid-size crossover	49	188	43.4
Minivan	56	209	39.2
Large pickup truck	67	252	33.0

Source: US EPA. * Real-world CO2 is typically 25 percent higher and real-world fuel economy is typically 20 percent lower than the CO2 and CAFE values discussed here. ** The fuel economy mpg targets shown in the last column would be higher if using the MPG-equivalent values corresponding to the CO2 emissions targets, i.e., if all CO2 reductions were achieved exclusively with higher fuel economy technologies

62% of Americans polled in 2013 strongly support the US EPA's aim of pushing for cleaner gasoline and vehicle emission standards (Source: American Lung Association).

EPA's proposed "Tier 3" standards for 2017

In March 2013, the US EPA announced proposals which would require cleaner gasoline and more effective emissions technologies. They would include reducing smog-forming VOCs and nitrogen oxides by 80%, reducing fuel vapour emissions to near zero and cutting vehicle emissions of toxic air pollutants, such as benzene and 1,3-butadiene, by up to 40%. A 70% tighter particulate matter standard was also recommended.

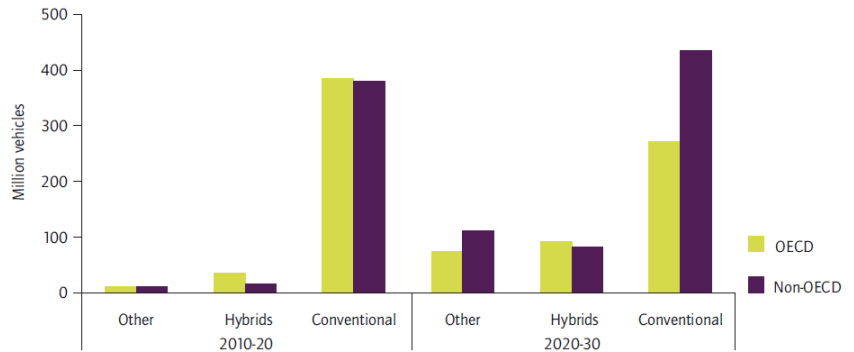
The EPA says the new regulations could avoid around 2,400 premature deaths and 23,000 cases of respiratory problems in children each year. A key component – lowering the sulphur content in gasoline by two-thirds – would be equivalent to taking some 33m cars off the roadways, around one in eight. If formally adopted following a public comment period, the new proposals, known as "Tier 3" standards, would go into effect by 2017. The EPA estimates that by 2030, the total health-related benefits from the new regulations could be as much as US\$23bn pa, a return of seven dollars for every dollar invested today (Source: US EPA).

But for consumers, evolution rather than revolution

While the shift to these new standards is arguably more aggressive than transitions implemented in the past and will likely result in additional cost to the industry, we continue to believe regulation alone is unlikely to drive a material move to all electric vehicles. Instead, we expect existing technologies geared toward making traditional internal combustion engines more fuel efficient to gain greater acceptance over the near term in the first stage of the evolutionary process. Our view that the internal combustion engine will remain the primary global engine technology appears to be shared by the International Energy Agency, which suggests that growth in conventional vehicles will meaningfully outpace those with alternative drivetrains through 2030.

Our view that the internal combustion engine will remain the primary global engine technology appears to be shared by the International Energy Agency, which suggests that growth in conventional vehicles will meaningfully outpace those with alternative drivetrains through 2030.

Chart 64: Forecasted worldwide light vehicle sales by technology type

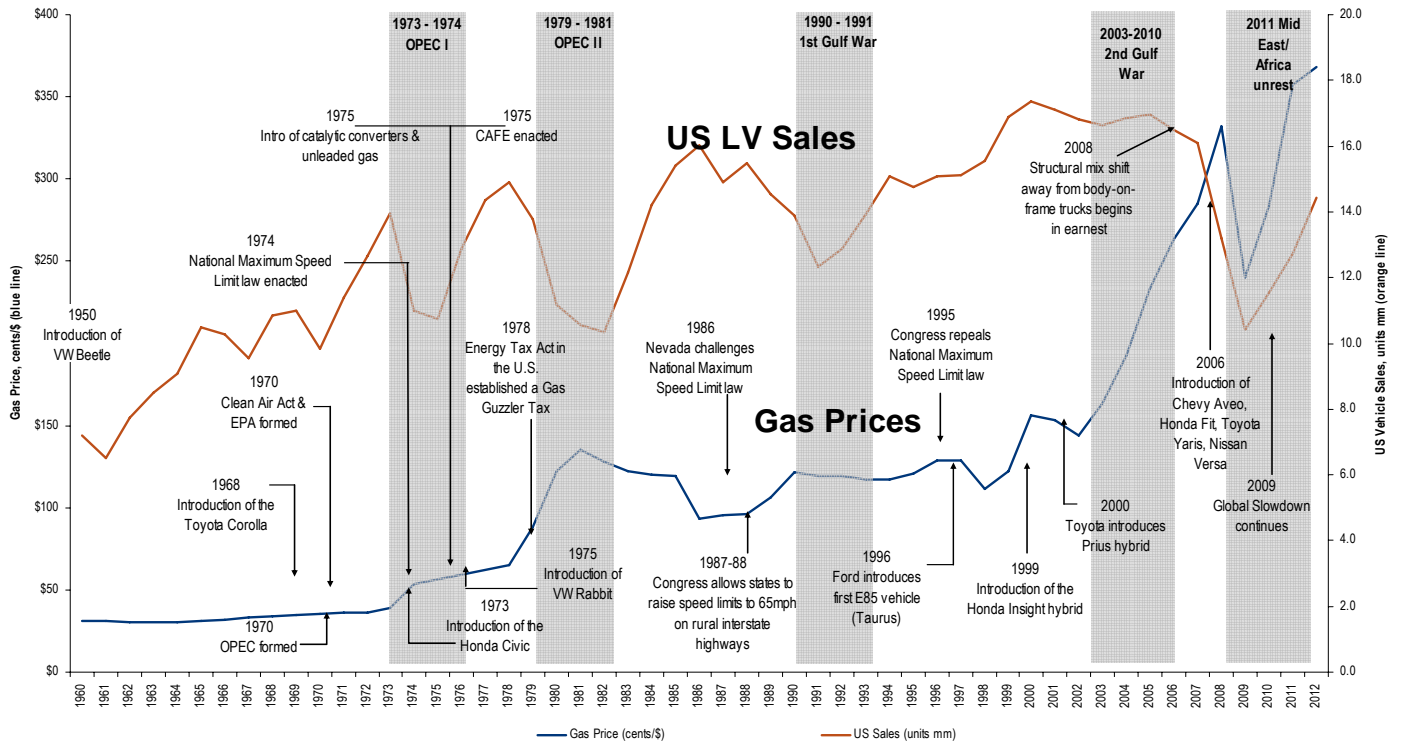


Source: International Energy Agency

Unless consumers are faced with an immediate financial impact or a major imminent national security risk, a significant change in consumption patterns is unlikely, in our view. We believe this trend is best illustrated by the generally muted demand and mix shifts historically experienced from rising gas prices; that is, until a short-term gas price shock (summer of 2008) or fears of a gasoline supply shortage emerges (OPEC I & OPEC II), rapidly driving up pump prices.

18 April 2013

Chart 65: Historical average retail gas prices, US Sales, and industry milestones

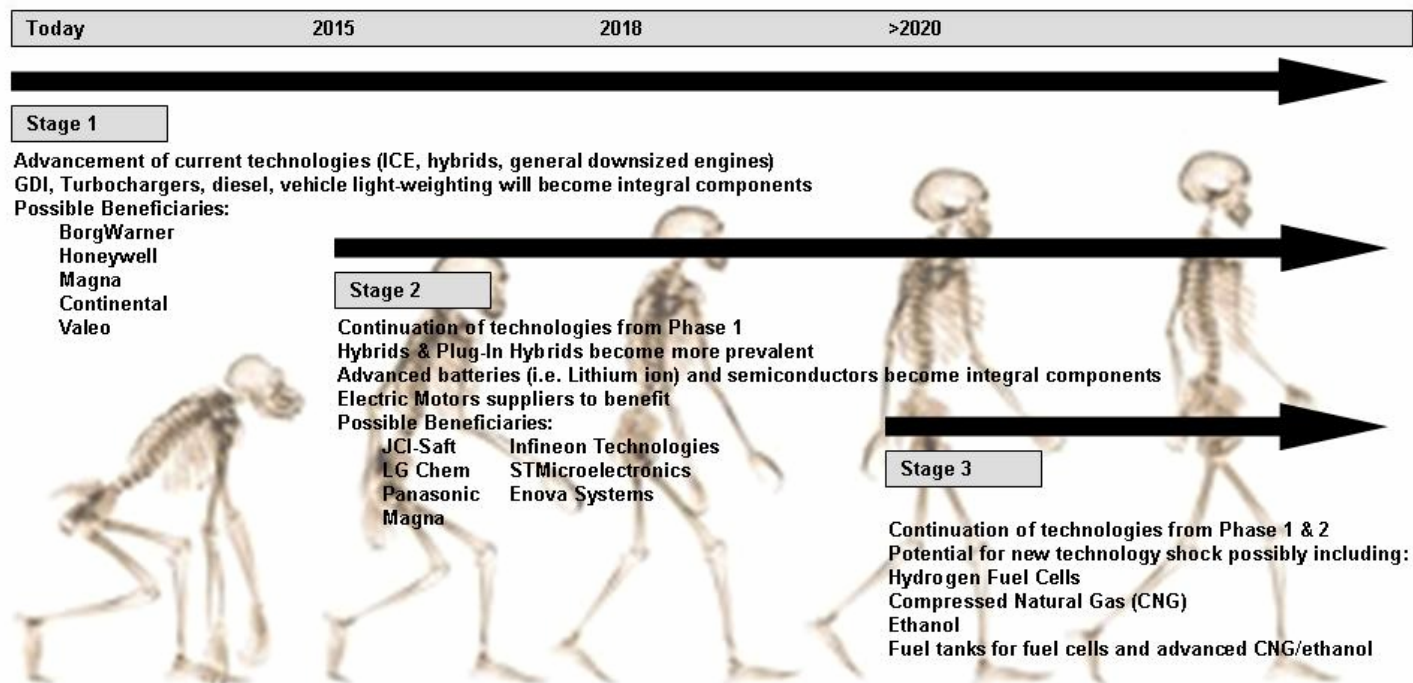


Source: Merrill Lynch, Energy Information Administration (EIA), industry sources

Three stages of fuel efficiency evolution

The estimated timing of the three stages outlined below is for illustrative purposes, but in the end could prove reasonably accurate, in our view.

Chart 66: The three likely stages of the “Green” Evolution



Source: BofA Merrill Lynch Global Research

The US department of energy estimates that only ~15-20% of the energy in gasoline actually reaches the wheels in the average ICE vehicle, which compares to an estimated 75% energy conversion from the battery in an electric vehicle.

Stage 1 (Present-2020), existing technologies

In our view, the simple conclusion of our analysis of stage 1 is that there are numerous ways to improve fuel economy and CO2 emissions using technology that is already in existence. Furthermore, many of these technologies add very little to the incremental price a consumer will pay for an average light vehicle. The table on the following page illustrates the estimated potential fuel savings, CO2 reduction, and incremental price to the consumer from incorporating select technologies onto the average light vehicle today.

In our view, suppliers with the greatest leverage to Stage I are those that develop components geared towards improving existing engine technology and reducing vehicle weight (e.g. BorgWarner, Honeywell, Magna)

Table 25: Estimated Fuel economy improvement, CO2 emission reductions, and cost of implementing existing technologies

	Technology	Reduction in fuel consumption	Reduction in CO2 emissions	Incremental price per vehicle
Engine	Low-friction lubricants	0.5%	0.5%	\$3
	Engine friction reduction	1-2%	1-3%	\$50-100
	Variable valve timing and lift	1-3%	3-4%	\$125-259
	Cylinder deactivation	2.5-3%	6%	\$150-169
	Turbocharged downsized engine	15-30%	20%	\$149-1,099
	Camless valve actuation	1-3%	5-15%	\$501
	Gasoline direct injection (stoichiometric)	2-3%	1-2%	\$209-346
Transmission	Continuously variable transmission	0.7-2%	6%	\$192-224
	Six-speed automatic	1.4-3.4%	4.5-6.5%	\$99
	Six-speed dual clutch	5-15%	5.5-13%	\$47-92
Vehicle	Aerodynamic drag reduction (20% cars, 10% trucks)	2-3%	2-3%	\$42
	10% reduction in tyre-rolling resistance	1-2%	1-2%	\$6
	10% reduction in weight	6-7%	6.5%	\$518-666
	High-efficiency alternator and electrified accessories	1-2%	1-2%	\$76
	Electric power steering	1-2%	1.5-2%	\$94

Table 25: Estimated Fuel economy improvement, CO2 emission reductions, and cost of implementing existing technologies

Technology	Reduction in fuel consumption	Reduction in CO2 emissions	Incremental price per vehicle
Integrated stop-start system	7-8%	7.5%	\$351-437
Hybrid motor assist	20-30%	20-30%	\$2,854-4,431

Source: EPA; NHTSA; BWA; BofA Merrill Global Research Estimates

We believe that the global automotive industry will likely continue its current trend of engine downsizing, with additional power and efficiency provided primarily through gasoline direct injection (GDI) and turbocharging.

GDI engines, turbochargers, diesel, and reduced weight

We believe that the global automotive industry will continue its current trend of engine downsizing, with additional power and efficiency provided primarily through gasoline direct injection (GDI) and turbocharging. Essentially, GDI and turbochargers allow for leaner and more efficient usage of fuel, thus reducing the need for larger engines to provide vehicle performance. We also believe turbocharged diesel engines could gain some support in NA, although we do not expect penetration levels to ever rival those of gasoline. Many US consumers continue to associate diesel technology with the loud and unpleasant odour emitting versions of the 1970s and 1980s, and therefore remain reluctant to revisit the technology. Finally, we expect vehicles to continue to be built lighter, a process that will likely be assisted by further proliferation of hydroformed structural parts.

Table 26: Existing technologies that stand to benefit during Stage 1

Technology	Overview	Deployment
Gasoline Direct-Injection (GDI)	Derivation of traditional fuel injection that generates its efficiency and emission reducing capabilities by directly inserting highly pressurized fuel into the combustion chamber of each cylinder. This process allows for a leaner and more powerful usage of fuel, thus reducing the need for larger engines	BorgWarner, in conjunction with CSM, JD Power, and Global Insight research, estimates that the use of GDI engines will grow from ~7% of the global engine market in 2010 to ~23% by 2015 and to ~35% by 2020. Delphi expects the global GDI market to expand at a 20% CAGR from just under \$1bn in 2010 to approximately \$5.5bn in 2020
Turbochargers	Use a vehicles exhaust to drive an internal turbine, which in turn forces compressed air into the engine, providing enhanced engine combustion/power. Essentially, turbochargers allow smaller engines to replace larger engines, without compromising power during acceleration and while improving fuel economy at constant speeds	BWA estimates that its turbochargers provide 15-30% fuel savings and up to 20% CO2 reduction. BWA forecasts solid expansion in the global turbocharger market, with an expected diesel turbocharger CAGR of 6% from 2012 to 2017 and a gasoline turbocharger CAGR of 18% over the same period
Diesel engines	Lower fuel cost point versus gasoline, ~25-40% improved mileage, an extended lifespan, lower carbon dioxide emissions, and high torque; generally come equipped with at least one turbocharger, which improves performance and results in fuel efficiency that rivals most hybrids.	Represent ~50% of European vehicle engines on the road today, will also occupy a position in this initial stage of transformation, especially outside North America

Source: BofA Merrill Lynch Global Research

Lose the pounds and gain fuel economy

We estimate the average curb weight of model year 2013 passenger car offerings (including electric vehicles) at approximately 3,600 pounds. In addition, we estimate the average curb weight of the group of MY13 CUV, SUV, van, and light truck offerings at approximately 5,100 pounds, for a total average MY12 light vehicle weight of roughly 4,300 pounds. As (Tables 23 and 24) on the following page indicate, we estimate that the vehicle component system with the largest weight contribution is Body & Structural at 29% and the largest raw material input in a vehicle is steel at 55%.

Hydroforming: Key Technology for Lighter Vehicles

Hydroforming¹ was developed by Magna in 1995 and remains a leading technology for developing lighter, stronger vehicles. We believe hydroforming will continue to play a key role in the automotive industry as OEMs work diligently to meet intensifying global fuel economy standards, the biggest opportunity being on light trucks.

Opportunities for speciality polymers

Speciality or high-performance polymers should be a beneficiary. They are materials that offer a wide range of high-performance attributes which make them particularly suited to replacing other materials (e.g. metals) in a number of growing niches. Some key attributes on top of those common features are: corrosion protection, biocompatibility, transparency, toughness, elasticity, flexibility of design, to name but a few. They should see growing use in the auto sector with the use of plastics progressing quickly thanks to its ability to reduce weight and its ease of assembly flexibility, which have enabled more complex designs and productivity gains. Arkema, Solvay and Victrex are possible beneficiaries (see further [Specialty polymers: punching above their weight, 20 February 2012](#)).

¹ Hydroforming is a process by which metal tubes are extruded into a desired shape by the injection of water at very high pressure (up to 100,000 PSI, but typically 30,000-60,000 PSI) into both ends

Table 27: Potential fuel economy improvements through weight reduction per 100 lbs

1) Baseline Gasoline Engine Fuel Economy Improvement (%) per 100 lb. Weight Reduction

Baseline Engine	City FTP75	Highway HWFET	EPA Combined	EURO ECE	30MPH	45MPH	60MPH	75MPH
Small Car	1.7%	1.1%	1.5%	1.3%	0.8%	0.7%	0.6%	0.5%
Mid-Size Car	0.8%	0.7%	0.8%	0.6%	0.1%	0.5%	0.4%	0.3%
Small SUV	0.8%	0.6%	0.7%	0.6%	0.3%	0.3%	0.4%	0.3%
Large SUV	0.7%	0.4%	0.6%	0.5%	0.3%	0.3%	0.3%	0.2%
Truck	0.7%	0.4%	0.6%	0.5%	0.2%	0.2%	0.3%	0.2%

2) Downsized Gasoline Engine Fuel Economy Improvement (%) per 100 lb. Weight Reduction

Downsized Engine	City FTP75	Highway HWFET	EPA Combined	EURO ECE	30MPH	45MPH	60MPH	75MPH
Small Car	2.7%	1.7%	2.3%	2.9%	2.2%	1.7%	1.3%	0.9%
Mid-Size Car	2.1%	1.5%	1.9%	2.2%	2.0%	1.4%	1.1%	0.9%
Small SUV	1.6%	1.1%	1.5%	1.9%	1.5%	1.2%	0.6%	0.3%
Large SUV	1.4%	0.9%	1.2%	1.6%	1.2%	1.0%	0.7%	0.5%
Truck	0.9%	0.6%	0.8%	0.8%	0.6%	0.5%	0.3%	0.2%

1) Baseline Diesel Engine Fuel Economy Improvement (%) per 100 lb. Weight Reduction

Baseline Engine	City FTP75	Highway HWFET	EPA Combined	EURO ECE	30MPH	45MPH	60MPH	75MPH
Mid-Size Car	1.2%	0.8%	1.0%	0.8%	0.7%	0.6%	0.5%	0.2%
Small SUV	1.0%	0.7%	0.9%	0.7%	0.3%	0.4%	0.4%	0.2%
Large SUV	0.9%	0.6%	0.8%	0.7%	0.4%	0.4%	0.3%	0.2%
Truck	0.7%	0.5%	0.6%	0.5%	0.3%	0.3%	0.3%	0.2%

2) Downsized Diesel Engine Fuel Economy Improvement (%) per 100 lb. Weight Reduction

Downsized Engine	City FTP75	Highway HWFET	EPA Combined	EURO ECE	30MPH	45MPH	60MPH	75MPH
Mid-Size Car	1.9%	1.3%	1.7%	1.9%	1.4%	1.2%	0.9%	1.2%
Small SUV	1.8%	1.0%	1.5%	1.8%	1.6%	1.0%	0.7%	0.8%
Large SUV	1.4%	0.9%	1.2%	1.5%	1.1%	0.7%	0.7%	0.7%
Truck	0.9%	0.6%	0.8%	0.7%	0.6%	0.5%	0.3%	0.3%

Source: Ricardo Inc.

City FTP75 -(Federal Test Procedure 75) test simulating city driving conditions

Highway HWFET (Highway Fuel Economy Test)

Euro ECE (European drive cycle test)

Cross Reference

[Tyre Industry, 14 January 2013](#)

If the use of low rolling resistance was progressively generalised, about 20Mt CO₂ emissions would be saved annually by 2020

For EVs, the impact of tyres can be 30%+ of total energy consumption

Tyres, 20% of fuel consumption

We also note that up to 20% of fuel consumption is influenced by tyre rolling resistance, which is generated when the rubber compounds are distorted. It is influenced by three main factors: tyre design, tyre rubber compounds and tyre inflation pressure. Low rolling resistance tyres are a partial, and growing, solution to this challenge with a 10% rolling resistance improvement resulting in approximately – 1.6% less fuel consumption and 2g less CO₂.

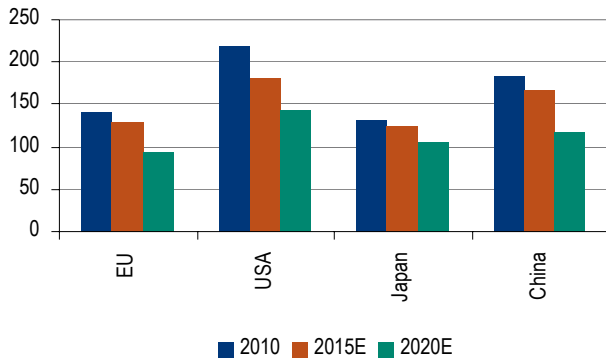
Key role for low rolling resistance tyres

Lower rolling resistance tyres should help light vehicle fleets to reduce CO₂ emissions by 3-5% by 2015. We estimate that rolling resistance improvements could contribute to 4.0-6.5g out of the 10gCO₂/km 2015 target reduction to come from tyres/air conditioning/etc, and reduce average car fleet emissions by 0.5gCO₂/km a year.

The automotive industry has increasingly recognised the importance of tyres to reduce fuel consumption. In 2006, the US National Research Council estimated that improving tyre rolling resistance by 10% would lead to a fuel consumption

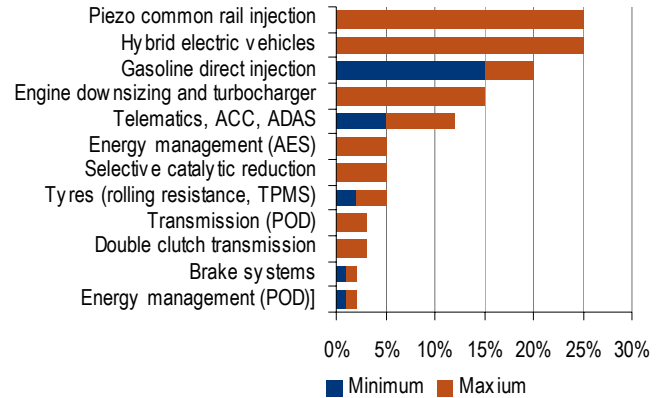
reduction of 1-2%. In 2008, a similar study ordered by the European Commission increased this projection, estimating that low rolling resistance tyres could reduce fuel consumption by 3%. More recently in 2011, the International Council for Clean Transportation (ICCT) estimated that tyres could reduce fuel consumption by 3-5% across existing car fleets.

Chart 67: CO₂ emission targets



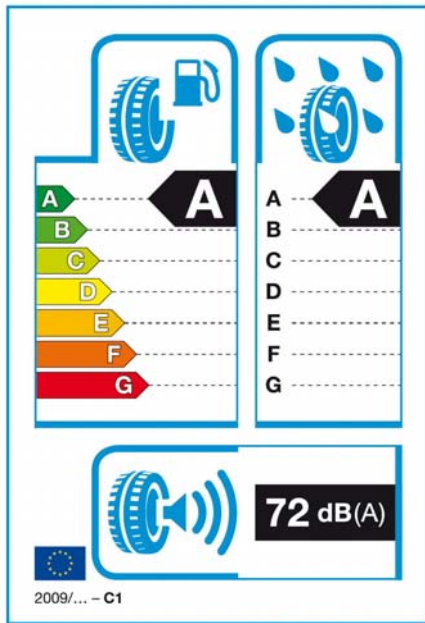
Source: Continental Fact Book 2011, BofA Merrill Lynch Global Research

Chart 68: Tyres can reduce CO₂ emissions by 2-5% according to Conti



Source: Continental Fact Book 2011

Chart 69: New labelling required from Nov 2012



Source: EU website

New performance criteria and labelling for tyres

We should see a further push on low rolling resistance tyres with new performance criteria and standardised labelling for tyres being introduced in Europe, Japan and South Korea in 2012 and the US in 2013.

- **Europe:** As of November 2012, under EU regulation 1222/2009, the tyre industry is required to meet tougher standards aimed at increasing energy efficiency. Suppliers of tyres for passenger cars, light and heavy duty vehicles (C1, C2 and C3 tyres) will have to inform consumers about fuel efficiency, wet grip and noise in any technical promotional materials, including websites. Re-treaded tyres, off-road professional tyres and racing tyres will be exempt from this requirement.
- **South Korea:** Voluntary tyre labelling in South Korea took effect on 14 November 2011 and became mandatory from November 2012. A label is placed on tyres and shows a grading based on five levels across the fuel efficiency and the wet grip characteristics. It will first be applied to passenger car tyres and light truck tyres, and later to truck and bus tyres.
- **Japan:** Voluntary labelling standards were adopted in 2010 and will become mandatory this year. They are technically at the same level as the EU standards and enable the establishment of a grading system by combining rolling resistance and wet grip performance.
- **US:** The Department of Transportation proposed in July 2009 a “tire efficiency consumer information program”. This proposed a label for replacement tyres, which will provide information about the tyre’s impact on fuel economy and CO₂ emission reductions from 2013.

Table 28: Tyre labelling in other car markets

Country	Tyre labelling status
Japan	Voluntary since 2010. Introduced by JATMA. Applies to replacement summer tyres for passenger cars; includes information on rolling resistance and wet grip performance. Tyres with grading of A and above for rolling resistance performance are defined as 'fuel efficient tyres' and are marked with an additional symbol.
USA	Final decision pending. Label proposed by NHTSA. The NHTSA Tire Fuel Efficiency Consumer Information Program proposes to inform consumers about the effect of tyres on fuel efficiency, safety and durability. The programme aims to implement a national tyre fuel efficiency rating system for replacement tyres, with the information. provided to consumers at the point of sale and online.
South Korea	Mandatory from November 2012. Introduced by South Korean Ministry of Knowledge Economy. Applies to all tyres sold in South Korea (OE and replacement) for passenger cars and light trucks; includes information on rolling resistance and wet grip performance. The label has to be attached to the tread of each tyre; for OE tyres the information has to be provided in the car manual Certification carried out by 3 authorities.
Brazil	Expect new tyre labelling rules to be published by end of 2012, with 4 years being proposed introductory period. Brazil's Institute of Metrology, Quality and Technology currently studying results from 30 day comment period on proposed label. Proposed label almost identical to EU version; tracks rolling resistance, wet grip and noise. Limits on rolling resistance and wet grip identical to EU limits in all categories of tyre (C1, C2, C3). Proposed noise limits are different, using absolute noise limits.

Source: Michelin 05-Nov-12 investor day presentation, European Rubber Journal, BofA Merrill Lynch Global Research

Limited impact for premium brands

Our European Autos team carried out a detailed price analysis on labelled tyres, and concluded that cheaper tyres were a limited threat to premium brands. Lower prices are justified by lower label ratings/tyre properties. Due to a technological gap, Asian entry-level players are unable to reach the highest ratings, which would be needed to capture premium consumers. Safety ranks first for car drivers: prices are 7% higher for tyres with a better wet grip vs 2% higher for better fuel efficiency.

Table 29: EU tyre labelling criteria

Criteria	Rating	Description	Comment
Wet grip/braking performance	A-G	Short to longer braking distance in wet conditions	Secure grip in wet conditions is crucial for safe driving. Performance is graded into classes, A to G (although D and G are not used). The stopping distance between a class A tyre and a class F tyre can be as much as 18 metres (when braking to a standstill from 80km/h)
	D,G	Not used	
Fuel efficiency/rolling resistance	A-G	Low to higher fuel consumption	Reduced rolling resistance saves fuel and cuts CO2 emissions. Class A tyres deliver the best fuel efficiency, with each subsequent class through to G increasing fuel consumption by between 0.10 and 0.15 l/100km for a car which does 6.6l/100km (or 0.42 and 0.56mpg for a car doing 36mpg).
	D	Not used	
Noise emission/exterior noise	3 classes	Measured in decibels	This is the external noise made by the tyre and is measured in decibels. The more filled bars shown on the label, the louder the tyres.

Source: Continental's guide to the new EU tyre label, BofA Merrill Lynch Global Research

Cross Reference

[FleetMatics Group PLC, 31 October 2012](#)

Fleet management, putting management in driver seat

Traditionally, fleet owners had little to no control over driver behaviour, and thus little control of driver behaviour related costs. It is easy to imagine how mobile employees who are out in a vehicle out of the office may get distracted easily and be less productive. Companies such as FleetMatics gives fleet managers a passenger seat view of driver behaviour, allowing companies to see ROI in as little as four days. There are several areas where cost savings can be realized by using a GPS tracking system and we have outlined some of them below.

Reduced vehicle speed drives fuel costs lower

Reducing driving speed can help realize drastic savings in fuel costs. According to the U.S. Department of Energy, gas consumption quickly begins to increase at speeds over 65 mph. Each incremental 5 mph adds on average \$0.20 per gallon to fuel costs. FleetMatics allows fleet owners to audit either fleet average or individual driver driving speeds. Fleet owners can also opt to receive notifications by email or within the FleetMatics interface if drivers exceed set speed limitations.

According to the U.S. Dept of Transportation, 87% of large truck crashes (where the truck is at fault) are caused by driver behaviour. Speeding plays a role in 23% of large truck crashes.

According to the EPA, each hour of idling time burns 0.82 gallons of fuel, whereas restarting an engine uses a very small fraction of that amount (the equivalent of about 30 seconds of idling time).

An Aberdeen Group study shows that companies using GPS tracking see a 23% increase in service calls completed per driver per day

Increased safety and decreased litigation saves on repair and legal costs

Another major implication of reduced driving speeds is increased safety. According to the U.S. Dept of Transportation, 87% of large truck crashes (where the truck is at fault) are caused by driver behaviour. Speeding plays a role in 23% of large truck crashes. Moreover, federal regulation CSA2010 allows the Federal Motor Carrier Safety Administration and local partners to inspect fleet safety and impose penalties on, or even closure of, out of compliance fleets. GPS tracking is the only effective method of enforcing driving policies and limiting at fault accidents as much as possible. FleetMatics products can help companies minimize costs resulting from tickets, lawsuits, accidents, injuries, repairs, missed work time, and regulatory penalties.

Decreasing idle time poses significant fuel savings

Idling time also adds fuel costs. According to the EPA, each hour of idling time burns 0.82 gallons of fuel, whereas restarting an engine uses a very small fraction of that amount (the equivalent of about 30 seconds of idling time). An Aberdeen Group study found that fleets installed with GPS tracking saved on average 13% on fuel costs.

Improved routing increases efficiency

Conventionally, fleet owners have little control over the routes their drivers decide to take. For example, drivers may elect to take the scenic route in order to make unauthorized stops along the way or rack up more work hours. This is clearly detrimental to fuel costs and pay expenses. Even if drivers do not have any intentions contrary to business best practices, they may not know the fastest route, may get stuck in traffic, or can get lost. Technologies such as FleetMatics' allow business owners to ensure that their drivers are minimizing time spent in traffic and take the most direct, fastest route to the job site. Moreover, fleet owners can improve dispatching efficiency and response times by ensuring that vehicles closest to the specific job location are dispatched. This not only helps save on fuel costs but also increases customer satisfaction.

Efficiency driving decreased overtime pay

Fleet owners can use FleetMatics to assure that their vehicles are only being used for authorized purposes and that time is spent productively throughout the workday. An Aberdeen Group study found that companies using GPS tracking technologies see a 23% increase in the number of service calls completed per driver per day, a 12.2% increase in service profitability, 27.9% increase in driver compliance, and a 9.9% reduction in overtime pay. FleetMatics ensures that their customers' employees are working as efficiently as possible, thus shortening the workday.

Ensuring timely vehicle maintenance

FleetMatics solutions allow fleet owners to set maintenance alerts for their vehicles to ensure timely repairs and general maintenance. Alerts can be set based on elapsed calendar time, engine-on time, or mileage depending on the type of maintenance. Maintenance alerts can be received via email or in the FleetMatics user interface. This allows small businesses, who may not have dedicated technicians, to catch any problems before they become more significant issues and to guard against preventable malfunctions or even driving accidents.

How does fleet tracking work?

FleetMatics data collection process is relatively straightforward with most of the technology focused on how it turns this data into easy to use reports for its customer. The below steps summarize the data collection and access lifecycle.

Chart 70: FleetMatics data collection and report generation process

1. FleetMatics utilizes 3rd party installers to outfit customer vehicles with a device that collects GPS data as well as engine diagnostic information.



2. Information is transmitted via standard CDMA/GPRS cellular data networks every 60 seconds to FleetMatics data centers



3. Data is stored by FleetMatics and processed to translate it into information that can be presented to users



4. Customers can access their information through FleetMatics dashboard on a web browser or from an app on their smartphones. FleetMatics offers various reports to provide insight including -

- Fleet Daily report - daily vehicle movement including ignition on/off time, drive time, distance traveled, etc.
- Journey Idling report - idle start/stop times, location of idling vehicle, alerts
- Hours Worked - electronic time-sheet like report with daily and weekly totals
- Red Flag report - Detects problematic behavior where a vehicle exceeds pre-set thresholds

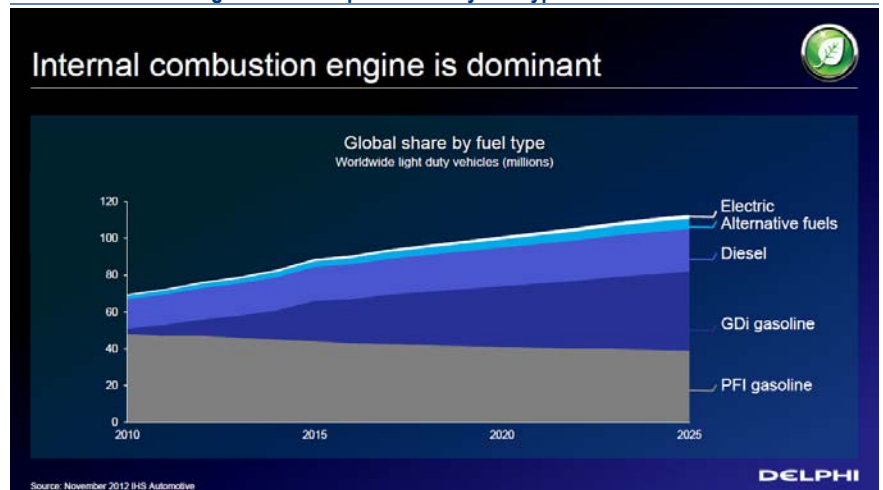
Source: FleetMatics, BofA Merrill Lynch Global Research

Suppliers likely to prosper during Stage 1

In our view, suppliers with the greatest leverage to Stage I are those that develop components geared toward improving existing engine technology and reducing vehicle weight. This view is supported by IHS, which forecasts that even by 2025 electric and alternative fuel vehicles will still only have low single digit market share of global automotive production.

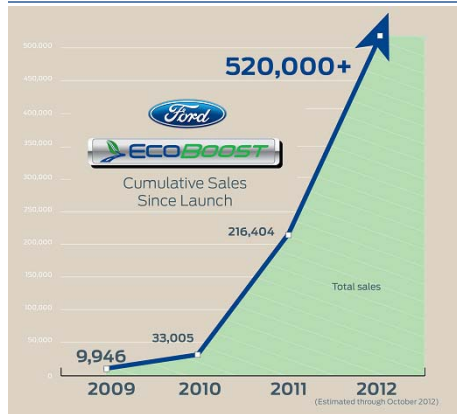
This view is supported by IHS, which forecasts that even by 2025 electric and alternative fuel vehicles will still only have low single digit market share of global automotive production.

Chart 71: Forecasted global vehicle production by fuel type



Source: IHS; DLPH

Chart 72: Ford EcoBoost sales

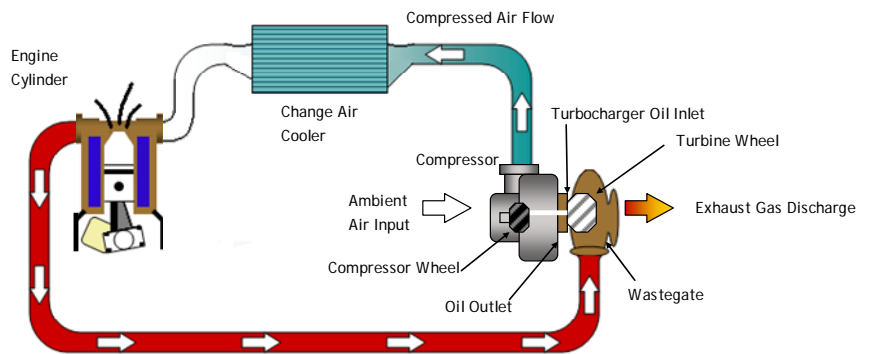


Source: Ford

In our view, suppliers with the greatest leverage to Stage I are those that develop components geared toward improving existing engine technology.

BorgWarner (BWA) and Delphi stand at the sweet-spot of this stage, in our view, with the former's products including turbochargers, timing chains, and dual clutch transmissions and the latter's advanced gas and diesel technologies, including gasoline direct injection (GDI), gas direct-injection compression ignition (GDICI), and diesel injection systems. Honeywell's (HON) Turbo Technologies division is another industry leader for turbochargers in Europe. Both BWA and HON are playing a pivotal role in Ford's EcoBoost system (gasoline & diesel turbo direct injection engines), which is expected to be available on 90% of Ford's North American vehicle lineup in 2013.

Chart 73: Turbocharger diagram



Source: BofA Merrill Lynch Global Research

Another supplier that we believe is positioned to benefit from the first stage of the green evolution is Robert Bosch, with its turbocharged GDI and diesel technology. Bosch predicts that diesel's share of new light vehicle purchases in the US will rise from the low single digits today to roughly 10% by 2015, citing company research indicating that 33% of US car buyers are now interested in diesel technology. In addition, as previously discussed, Magna should continue to be a leading provider of light-weight hydroformed auto parts, while American Axle's and Dana's light-weight axle and driveline components and Dana's fuel efficient Power Tech offerings should also be in high demand.

Table 30: Estimated Fuel economy improvement, CO2 emission reductions, and cost of implementing existing technologies

	Technology	Reduction in fuel consumption	Reduction in CO2 emissions	Incremental price per vehicle
Engine	Low-friction lubricants	0.5%	0.5%	\$3
	Engine friction reduction	1-2%	1-3%	\$50-100
	Variable valve timing and lift	1-3%	3-4%	\$125-259
	Cylinder deactivation	2.5-3%	6%	\$150-169
	Turbocharged downsized engine	15-30%	20%	\$149-1,099
	Camless valve actuation	1-3%	5-15%	\$501
	Gasoline direct injection (stoichiometric)	2-3%	1-2%	\$209-346
Transmission	Continuously variable transmission	0.7-2%	6%	\$192-224
	Six-speed automatic	1.4-3.4%	4.5-6.5%	\$99
	Six-speed dual clutch	5-15%	5.5-13%	\$47-92
Vehicle	Aerodynamic drag reduction (20% cars, 10% trucks)	2-3%	2-3%	\$42
	10% reduction in tire-rolling resistance	1-2%	1-2%	\$6
	10% reduction in weight	6-7%	6.5%	\$518-666
	High-efficiency alternator and electrified accessories	1-2%	1-2%	\$76
	Electric power steering	1-2%	1.5-2%	\$94
	Integrated stop-start system	7-8%	7.5%	\$351-437
	Hybrid motor assist	20-30%	20-30%	\$2,854-4,431

Source: EPA; NHTSA; BWA; BofA Merrill Global Research Estimates

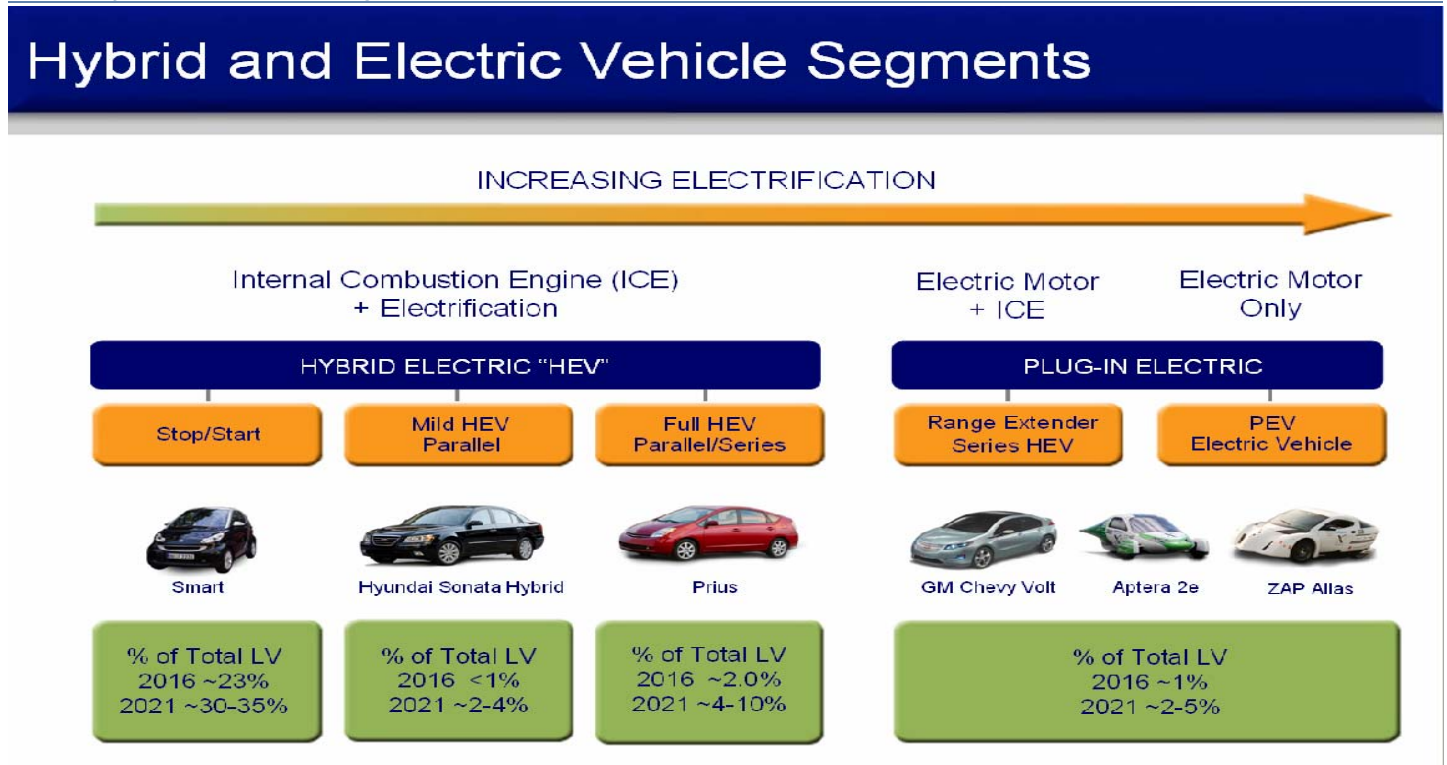
We believe it will take at least 5 to 10 more years before advanced battery technology is perfected and made affordable for mainstream use in automobiles

Stage 2 (2016-20+), hybrids & EVs

In our view, current electric motor technology is sufficient to meet most, if not all, requirements of hybrid and EVs, although the efficiency of these components continues to improve each year. However, we believe that it will take at least 5-10 more years before advanced battery technology is improved to a level that makes it affordable for mainstream use in automobiles. Furthermore, it is likely to take at least this much time for the requisite infrastructure to be established to support battery recharging in the US. When these obstacles are addressed, we believe that hybrid and EVs could become more prevalent, due to their increased efficiency and reduced impact on the environment.

We believe Stage 2 will be dominated by suppliers who manufacture electric motors, advanced automotive batteries, and the semiconductors, connectors, and sensors that allow these advanced hybrid and electric systems to communicate with one another

Chart 74: Hybrid & Electric Vehicle Segments



Source: BWA; CSM

Hybrid Electric Vehicles (HEV)

All-electric vehicles are aspirational but are the basis of a disruptive business.

HEVs can be divided into three broad categories: mild HEVs, full HEVs, and plug-in hybrid electric vehicles (PHEVs).

Table 31: Three main categories of HEVs

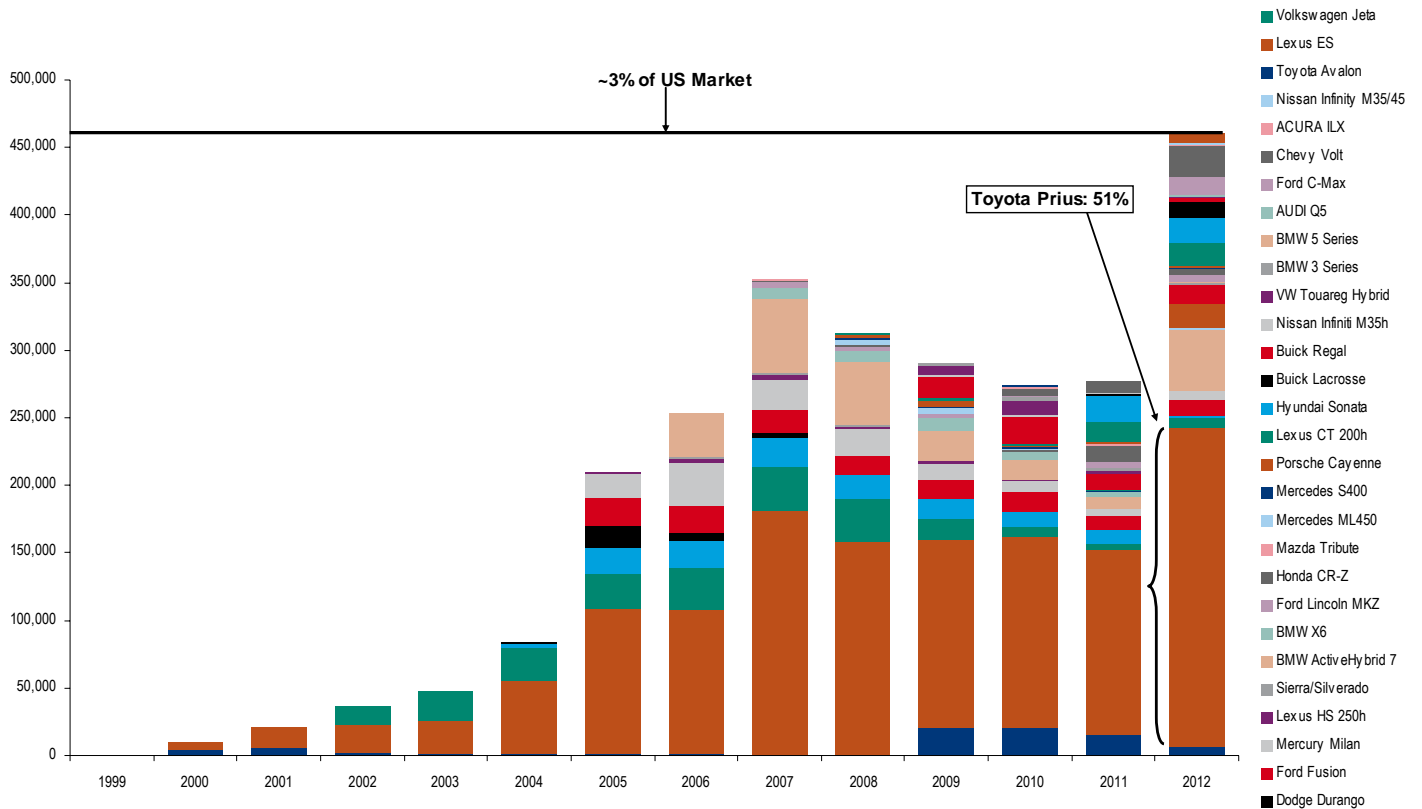
Technology	Overview	Fuel savings	Cost	Deployment
Mild HEVs	Employ a series drive train and regenerative braking capability in which the battery provides some electric power to propel a vehicle; the vehicle's internal combustion engine is always running, and the electric motor provides power in a supplemental fashion	Enables a mid-size car to improve average fuel economy by approximately 20% (to 35 MPG) and reduce its emissions over a standard internal combustion vehicle by 20%	Estimated incremental cost is approximately \$600-1,200	well suited for vehicles that operate in a stop-and-go fashion at low speeds
Full HEVs	Employ a parallel or dual system drive train and regenerative braking capability in which the battery can	Enables a mid-size car to improve average fuel economy by approximately	Estimated incremental cost is approximately \$800-	Toyota Prius (dual drive train) commands more than a 75%

Table 31: Three main categories of HEVs

Technology	Overview	Fuel savings	Cost	Deployment
	provide electric power to propel a vehicle autonomously under certain conditions; the combustion engine is directly connected to the wheels, which eliminates the inefficiency of converting mechanical power to electricity and back	40% (for 40-60 MPG) and reduce its emissions over a standard internal combustion vehicle by 30%	2,200.	market share of full hybrid vehicles
Plug-in hybrids (PHEVs) and EVs	PHEVs use the same three drive train architectures found in HEVs, but PHEVs use an energy-dense battery that enables the vehicle to rely more on electric power throughout a given trip Battery Electric Vehicles (BEVs), commonly referred to as EVs, do not have an internal combustion engine. The vehicle operates solely from stored electric energy from the grid and does not have backup	Fuel economy varies according to how the battery energy is used: -Charge depleting mode -Blended mode -Charge sustaining mode -Mixed mode	Varies	Full commercialization of EVs will take time (creating the EV ecosystem and enhancing battery density while lower costs will be key determinants).

Source: BofA Merrill Lynch Global Research

Chart 75: US hybrid-electric vehicle market



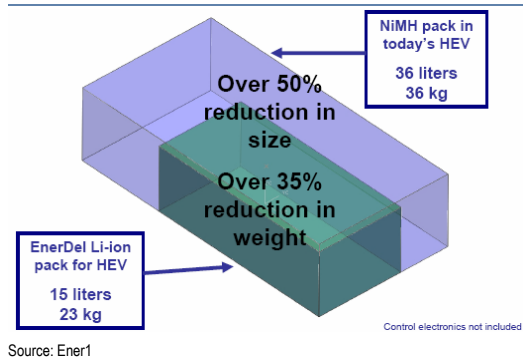
Source: US Department of Energy; Wards
***Illustrative, not exhaustive

In terms of powering the drivetrain of hybrid and electric vehicles, permanent magnet motors and induction motors are the prevailing technologies

What types of electric motors are used?

While over 50 electric motors may be installed in an average vehicle, most are low power output versions used to control electric seats, windshield wipers, parking breaks, etc. However, in terms of powering the drivetrain of hybrid and electric vehicles, permanent magnet motors (brushless) are by far the most prevalent (90%+), though induction motors are being used on high-end performance vehicles such as the Tesla Roadster.

Figure 1: EnerDel Li-ion vs. NiMH battery pack



Permanent magnet motors, which began in brush form but are now almost exclusively brushless when used to power automobile drivetrains, gained popularity due to their exceptional efficiency and high power density. However, the raw earth metal magnets create additional cost and potential scarcity of supply.

Batteries 101: Game Ion

Lithium-ion (Li-ion) batteries are gaining momentum as the preferred technology to power the next generation of vehicles. Other advanced battery technologies, such as nickel-metal hydride (NiMH), come up short because the energy density is small compared to Li-ion chemistries. For example, Ener1 replaced a Prius NiMH battery pack with a Li-ion battery pack and achieved twice as much power and density. The same shift that was seen in the consumer electronics battery market from NiMH to Li-ion is playing out in the quest for automotive-grade batteries and largely for the same reasons: longer life, greater reliability, and higher energy density.

What you auto know

To penetrate the auto market, battery makers will need to (1) develop their battery chemistries and packaging to best meet the specifications required by each vehicle type (HEV, PHEV, or EV), (2) perfect the manufacturing process to have consistently reliable products, and (3) successfully scale to drive costs down.

- **No silver bullets for battery chemistries:** Key characteristics that matter in an automotive-grade battery: energy, power, energy density, cycle life and safety.
- **Chemistry:** A wide range of combinations emerges by changing these variables, leading to multiple uses. This is why comparisons between battery chemistries are only relevant when taking into account the application.
- **Chemistry-related costs:** The electrification of the automobile is still in its infancy, but “peak lithium” is already a concern. But based on expert forecasts, there should be some 30Mt of lithium readily available to be mined. At volume, H/EVs might use 70,000t/y. In addition, the lithium in a battery, which is about 3% of total battery cost, can be recycled. Of the active materials employed, cobalt has exhibited a high degree of volatility since 40% of global supply derives from the Katanga Province of the Democratic Republic of Congo
- **Reducing battery costs:** Our analysis indicates that costs per kWh for lithium-ion batteries are close to US\$800 per kWh after accounting for production costs, production yield adjustment, lack of scale, and a poor components supply and distribution network. OEMs we’ve spoken with indicate that battery costs will need to come down by 33-50% over the next five years for EVs to begin to achieve meaningful penetration rates. Cost reduction measures include technological changes, working with a domestic supply chain, improving coater speed and doubling the speed of all manufacturing processes.
- **Material costs:** Materials constitute the majority of battery costs at more than 80% of cell and 90% of pack costs. Battery makers are addressing this constraint through advances in packaging, improvements in manufacturing yield, forming alliances across the EV supply chain, and selecting the optimal cost-performance chemistry.

According to a 2009 Harris Interactive/Johnson Controls survey, 80% of Americans see cost as the barrier in buying an electric vehicle

Improving manufacturing yield is an important step in reducing the cost of electric vehicles. Some industry observers claim that sub-par yields can result in a 30-40% increase in the cost of goods sold

- **Manufacturing yield:** Lithium-ion production is a highly complex process incorporating various materials, chemistries, hardware, and software – with automotive-grade batteries requiring a higher degree of quality control than do consumer batteries. Experienced large-scale battery makers such as Panasonic and Samsung have the benefit of many years of high volume production, potentially making the transition from consumer battery to automotive-grade production easier. Employing a high degree of manufacturing automation is another step manufacturers can take to improve yield. Newer entrants that may have demonstrated capable technology at smaller scales could be more susceptible to production difficulties and higher manufacturing costs as the market for EVs increases. As the competitive environment for OEM supply contracts heats up, early market share winners and losers will be ultimately determined by their respective manufacturing yield, in our view.
- **Strength in the supply chain:** EV manufacturing integrates a host of ingredients from a variety of suppliers across a very diverse value chain. At this point in the industry's evolution, the auto maker appears to be calling the shots and setting the tempo. However, it's likely that charging infrastructure developers and utilities will gain stronger voices as adoption grows.
- **Alliances forming:** There are a number of solid players with large resources in the automotive battery space. Primearth (Panasonic/Toyota) and AESC (NEC/Nissan) have to top the list. A123 says it most sees LG Chem, Johnson Controls-Saft, and Ener1, which are its counterparts in the Automotive Battery Consortium. Although many battery-car partnerships have been announced, the EV industry is new enough that partners could change. Also, there are expected to be second sources on most contracts since no car maker wants to put all its eggs in one basket.

Semiconductors are becoming increasingly prevalent in non-hybrid/electric vehicles as well, which should add to the potential automotive growth opportunity for manufacturers of these components

Semiconductors are also key

Given the increased complexity of the electronics in hybrid and EVs, we believe semiconductors will also be critical to Stage 2 of the automotive evolutionary process. Very simply, semiconductors are the brains that allow the sophisticated components of advanced vehicle architectures, such as the battery and electric motor, to effectively communicate. The degree of electric performance required varies directly with the degree of hybridization of the vehicle. According to GM Powertrain specialists, these "chips" account for approximately 20% of the incremental cost of a hybrid vehicle. We would also note that semiconductors are becoming increasingly prevalent in non-hybrid/electric vehicles as well, which should add to the potential automotive growth opportunities for these companies, in our view.

US\$35bn industry by 2017E

The automotive semiconductor market is forecast to grow to more than US\$35bn in 2017E (Source: Gartner, Automotive Electronics, Worldwide, 1Q13 Update). Communication and entertainment ("infotainment"), safety, telematics, and environmental initiatives are all boosting the auto semi market – as is the trickle down of sophisticated technologies from premium to lower- and mid-range vehicles. Leading companies in the space include: Renesas Electronics, Infineon Technologies, STMicroelectronics, Freescale Semiconductor, and NXP Semiconductor who account for 41.6% of the market (Source: Semicast Research).

Suppliers likely to prosper during Stage 2

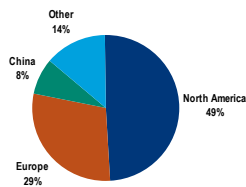
We believe Stage 2 will be dominated by suppliers who manufacture electric motors, advanced automotive batteries, and the semiconductors, connectors, and sensors that allow these advanced hybrid and electric systems to communicate with one another.

Electric Motors

In terms of electric motors, we believe large, geographically diversified suppliers like Magna are well positioned to lead the charge. Other smaller and more specialized companies should also benefit from expansion in this market. Business research and consulting firm Frost and Sullivan forecasts a 44mm unit global market for traction electric motors by 2017, with two-wheel vehicles in China accounting for a large portion of the total. In fact, the company estimated electric motors for two-wheel vehicles in China will grow at a 9% CAGR from 19 million units in 2009 to 37 million 2017.

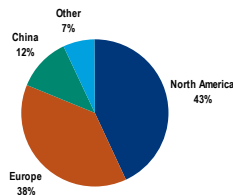
This would imply a global market for hybrid and electric vehicles (ex two-wheelers) of approximately 7 million units by 2017, or a 30%+ CAGR. In addition, using LMC forecasts for total global LV production of approximately 106 million units in 2017, 7 million units of hybrid and electric vehicles would represent 6.6% market share (<1% currently). While we view this growth forecast as optimistic, it is undeniable that a solid opportunity exists for electric motor manufacturers.

Chart 76: Global Hybrid Electric mkt – 2017



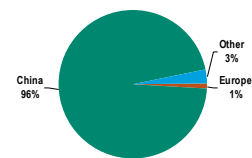
Source: Frost & Sullivan

Chart 77: Global Electric mkt – 2017



Source: Frost & Sullivan

Chart 78: Global 2-Wheel Electric mkt – 2017



Source: Frost & Sullivan

The greatest risk for electric motor suppliers is for OEMs to increasingly in-source the manufacturing of this component because of its inherent importance to hybrid and electric vehicles and the opportunity for differentiation, in our view. This trend would not be dissimilar to how OEMs view the engine in traditional ICE vehicles. Business research and consulting firm Frost and Sullivan estimated that 60% of OEMs currently outsourcing electric motors plan to bring the technology in-house.

Battery and semiconductors

While we expect battery and semiconductors to be critical to Stage 2 of the Green Evolution, it is more difficult to determine which companies will be the primary beneficiaries because the technologies are still evolving rapidly. Large, well-funded battery suppliers such as JCI and Panasonic are likely to be in the mix, in our view, while semiconductor, connector, and sensor manufacturers with automotive experience, such as Infineon, STMicroelectronics, TE Connectivity, Freescale, Renesas, and Molex could ultimately prevail.

Stage 3 (2020 and beyond): exogenous technology shock may be needed

Beyond the next 10 years it is possible that a technology not yet discussed may solve the fuel efficiency/emission conundrum. A few potentially viable alternatives for the automotive industry include fuel cell technology, compressed natural gas,

and ethanol. However, lack of infrastructure (fuelling stations) and prohibitively high cost points (lowering price will require scale) remain significant headwinds for most options. Therefore, we believe a shock that renders Stage 1 & 2 technologies no longer viable or that provides a solution to current constraints for Stage 3 technologies may be necessary for the final step in vehicle evolution to gain a foothold.

In our view, suppliers with the greatest leverage to Stage 3 are those developing fuel cell technology and more viable methods of transporting and storing natural gas and ethanol.

Table 32: Possible stage 3 technologies

	Deployment	Advantages	Challenges
Fuel Cells	<ul style="list-style-type: none"> •Technology has been viable for decades (Apollo space missions) •OEMs have developed and distributed (on a very limited basis) fuel cell cars for use in test fleets 	<ul style="list-style-type: none"> •Complete lack of a carbon footprint (only emission is water) •Potential economic savings (hydrogen is a naturally occurring element in the atmosphere) 	<ul style="list-style-type: none"> •very high cost of production •lack of infrastructure for refuelling
Compressed Natural Gas (CNG):	<ul style="list-style-type: none"> •Penetration in vehicle fleets: Pakistan 61%, Bolivia: 20%, Argentina: 12%, Brazil: 3%, US: <1% 	<ul style="list-style-type: none"> •Compared to gasoline: reduces CO emissions 90-97%, CO2 25%, NOx 35-60%, non-methane hydrocarbons 50-75%, fewer toxic and carcinogenic pollutants, little or no particulate matter •Supply of CNG in the US is abundant 	<ul style="list-style-type: none"> •Highly flammable NG must be compressed at significant pressures (~3,600 psi) to store ample fuel in a vehicles tank. This could create inherent fire and explosion risk, particularly when considering a high speed collision scenario
Ethanol	<ul style="list-style-type: none"> •Has been around for years and are among other alternative engine technologies to receive media attention. 	<ul style="list-style-type: none"> •E10 is compatible with current distribution infrastructure •E85 offers more significant emissions improvement 	<ul style="list-style-type: none"> •E10 does not offer significant emissions reduction •E85 requires a new distribution infrastructure since the ethanol corrodes current materials used to distribute petrol •Lack of consumer knowledge and distribution headwinds

Source: BofA Merrill Lynch Global Research

Perhaps the most challenging hurdle that the alternative vehicle industry faces is lack of infrastructure

Convenience vs. the environment

Perhaps the most challenging hurdle that the alternative vehicle industry faces is lack of infrastructure. Arguably, the issue is that of chicken versus egg. Companies are likely unwilling to invest in the requisite infrastructure to support alternative technologies, such as fueling stations, until sufficient consumer demand is in place. On the other hand, consumer demand is unlikely to grow substantially until owning, fueling, and servicing alternative vehicles is as convenient as it is for traditional internal combustion engine vehicles. Table 28 on the following page below compares the aggregate number of alternative fueling stations by state and fuel type versus gasoline stations. In total, the EPA estimates that approximately 23,600 alternative fueling stations exist in the US compared with 131,500 gasoline stations nationwide.

In our view, the lack of supportive infrastructure for alternative automotive technologies is a significant roadblock that is unlikely to be overcome without substantial investment by the US government. We believe that stage three of the green evolution could be jump started by a significant degree of government stimulus supporting alternative vehicle infrastructure.

Buildings - the easiest & largest efficiency gains

Table 33: BofAML Buildings & Energy Efficiency Stock List

Company	EE exposure
INGERSOLL RAND	High
ITRON	High
KONE	High
LEGRAND	High
MELROSE	High
OWENS CORNING	High
SAINT-GOBAIN	High
CSR LIMITED	Medium
ELECTROLUX	Medium
GENERAC	Medium
HOME DEPOT	Medium
JOHNSON CONTROLS	Medium
HONEYWELL INTL.	Medium
LOWE'S COMPANIES INC	Medium
PHILIPS	Medium
NIPPON SHEET GLASS	Medium
SCHNEIDER	Medium
UNITED TECHNOLOGIES	Medium
REXEL	Low
WHIRLPOOL	Low

Source: BofA Merrill Lynch Global Research. * EE exposure = BofAML estimates of current sales derived from energy efficiency products, services, technologies and solutions.

Energy consumption within buildings is the single largest component of global energy use and CO2 emissions, at c.40% and c.30%, respectively.

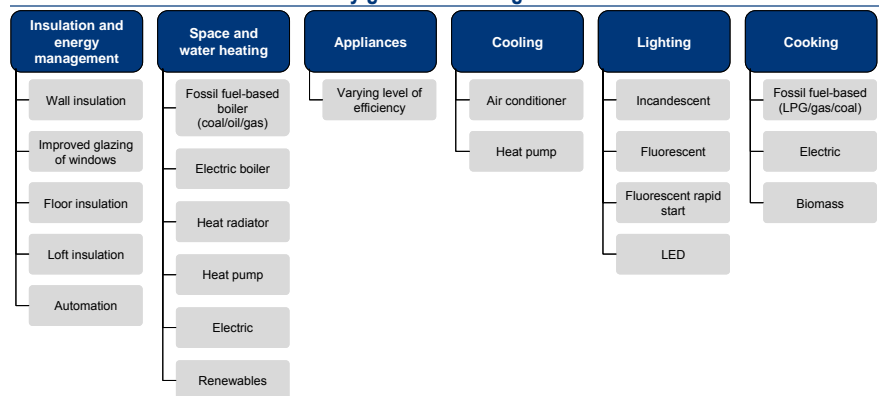
The biggest culprits are heating and cooling, which, together with lighting, can account for up to 60% of a building's energy consumption. We believe that improved energy efficiency in the buildings sector offers the greatest potential of any sector to make cost savings and reduce energy use – by 30% to 50% by 2030-50, respectively, according to the IEA. Moreover, little of this has been captured – with 80% of the economic potential of energy efficiency in buildings remaining untapped, largely due to challenging non-technical barriers (source: IEA).

In addition to a housing sector rebound, the biggest driver for improving energy efficiency in buildings is reduced energy use and therefore costs; it also lowers the capex needed in energy infrastructure, and promotes energy security. The average payback for efficient building technologies is only three years in terms of electricity and 9-14Y for fuels (source: IEA). Long-term growth drivers are extremely favourable, in our view, and include: high energy and electricity prices, stricter regulations and building codes, ageing stock, increasing renovation/DIY, EM urbanisation and growth, favourable demographics, efforts to lower CO2 emissions, affordable housing, tackling fuel poverty, realising a green premium on green buildings, the low-risk nature of financing efficiency, and the economic importance of the sector in terms of GDP and jobs.

The global market for energy-efficient building technologies is expected to increase from US\$68bn in 2011 to US\$103.5bn in 2017 – a CAGR of 7.25% (source: Pike Research). The “green” or energy-efficient building market in the US alone has grown from US\$10bn in 2005 to US\$85bn in 2012, and is expected to reach US\$98-106bn in 2013 and US\$204-248bn by 2016 (source: McGraw-Hill Construction)

We believe a number of stocks are well placed to benefit from the theme of energy efficiency in buildings, including those with exposure to: building automation, energy services (ESCOs), efficient HVAC, insulation materials and technologies, high-efficiency lighting (including LEDs) and appliances, windows (including multiple glazing and low-e), and the distribution of building products.

Chart 79: Potential end-use efficiency gains in buildings



Source: IEA WEO Outlook 2012, BofA Merrill Lynch Global Research

#1 source of energy use & emissions

Energy consumption within residential, commercial and public buildings accounts for c.40% of energy use in most countries and c.30% of global CO2 emissions (source: IEA). The figures are higher in developed markets, with buildings accounting for closer to 40% of both energy demand and CO2 emissions in the EU and US (source: EU, EIA).

Table 34: Building sector's share of energy consumption & CO2 emissions

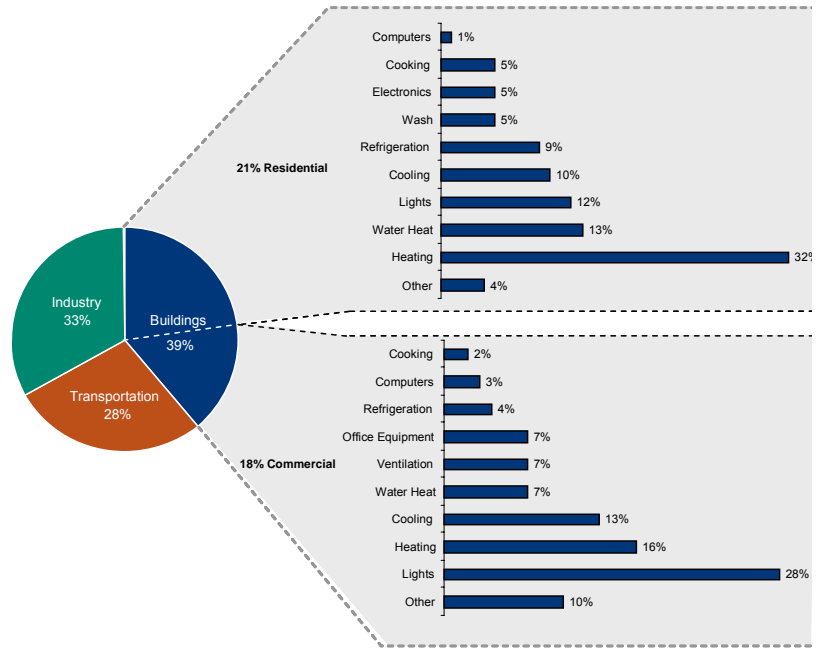
Region/Country	Total Buildings Sector								Residential				Commercial & Public								
	Primary Energy Use	Delivery Energy	Electricity	Emissions	Primary Energy Use	Delivery Energy	Electricity	Emissions	Primary Energy Use	Delivery Energy	Electricity	Emissions	Primary Energy Use	Delivery Energy	Electricity	Emissions					
% total	EJ	Quads	% total	TWh	% total	Gt	% total	EJ	Quads	% total	TWh	% total	Gt	% total	EJ	Quads	% total	TWh	% total	Gt	
Global	38%	109	77.0	51%	7995	33%	7.1	29%	82	50.3	28%	4309	21%	4.5	9%	27	26.4	24%	3686	12%	2.6
Australia			0.7	53%	111				0.4	30%	62				0.3	23%	49				
Brazil		1.3	1.0	46%	174				0.6	23%	86				0.4	0.4	24%	88			
Canada	29%			55%	292			16%	0.9		155			13%			26%	137			
China		5.6	7.1	21%	491				5.2	14%	335				1.7	1.9	7%	156			
EU								13.9													
France				64%	274					34%	147						29%	127			
Germany				52%	272					27%	142						25%	130			
India		7.1	1.6	29%	146				6.6	1.3	21%	108			0.5	0.3	8%	39			
Indonesia				61%	69						39%	44					22%	25			
Italy				47%	146						22%	68					25%	78			
Japan			5.0	65%	640				2.1	29%	280				2.9		37%	261			
Korea				46%	172						14%	53					32%	120			
Mexico		0.9	0.5	37%	70				0.7	0.4	25%	48			0.2	0.1	11%	22			
Russia		6.0	5.3	33%	225				4.6	4.2	17%	113			1.4	1.1	16%	112			
S. Africa		0.8		33%	66				0.6		19%	38			0.2		14%	28			
UK				62%	214						34%	116					28%	97			
USA	39%		19.0	71%	2651	38%	2.2	21%	10.8	36%	1352	20%	1.2	18%	8.2	35%	1300	18%	1		

Source: IEA, EIA, Government of Canada, BofA Merrill Lynch Global Research

Heating, cooling & lighting are the biggest culprits

The largest proportion of energy use in buildings is for heating and cooling, as well as providing hot water. In the US, for instance, the top three end uses – space heating, water heating, and lighting – account for close to 60% of both energy consumption (source: IEA) and building-related emissions (source: US DOE).

Chart 80: Energy consumption of buildings in US

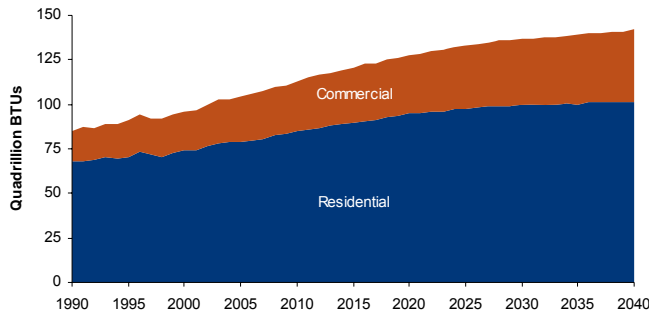


Source: Centre for Sustainable Building Research, BofA Merrill Lynch Global Research

Energy demand set to increase to 2040-50

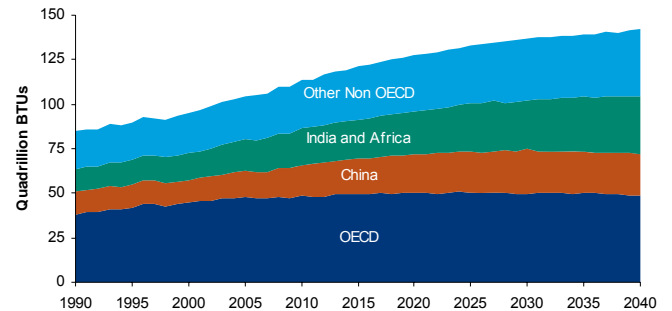
Energy demand from buildings has been on the rise for many years. In the US, primary energy consumption from buildings increased by 50% between 1980 and 2008. Projections are that demand in the sector will increase by 60% by 2050, meaning significant rises in energy demand and CO2 emissions unless we see concerted action to improve energy efficiency (source: IEA, OECD). This increase will be driven by a 67% rise in the number of households, a near tripling of the service sector building area, higher ownership rates for existing energy consuming devices and increasing demand for new types of energy services. By 2040, electricity will provide nearly 40% of the world's residential/commercial energy demand (source: Exxon Mobil).

Chart 81: Energy demand for residential/commercial buildings



Source: Exxon Mobil, BofA Merrill Lynch Global Research

Chart 82: Energy demand for residential/commercial by region

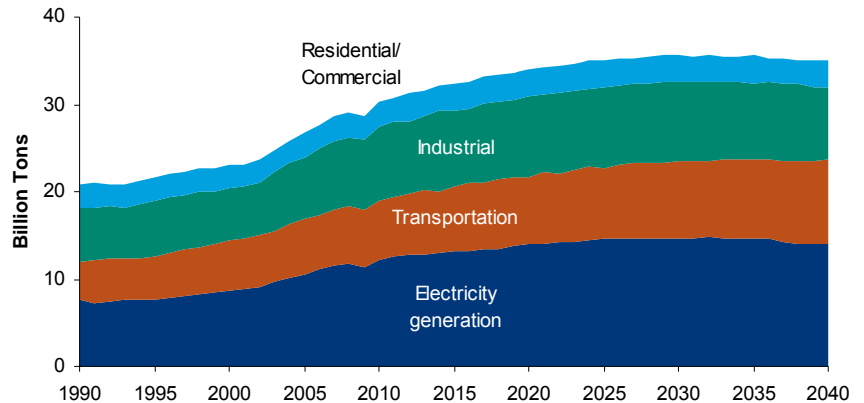


Source: Exxon Mobil, BofA Merrill Lynch Global Research

60% CO2 increase projected by 2050

Buildings-related CO2 emissions are expected to increase by 60% by 2050 – which is greater than projections for both industry and transport (source: IEA, OECD). This is being fuelled primarily by growth in populations, households, and commercial and residential floor space, all of which are expected to increase by 30-40% between 2008 and 2035 (source: IEA), as well as by increased electric water heating in emerging markets (source: Vattenfall).

Chart 83: Energy-related CO2 emissions by sector



Source: Exxon Mobil, BofA Merrill Lynch Global Research

World average per capita residential electricity consumption is c.600kWh/y but reaches 1,500kWh/y in W. Europe and >4,000kWh/y in NAm (source: WEC)

Energy & cost savings, the key drivers

Residential and commercial buildings consume 40% of global energy consumption – and energy consumption is one of the fastest-growing areas of energy use, especially in emerging markets (eg, growing water heating and AC). The IEA estimates that the energy saving potential in the building sector will be in the range of 20 EJ per year by 2030, which is the equivalent of the current annual electricity consumption of the US and Japan combined.

10-30%+ in energy savings

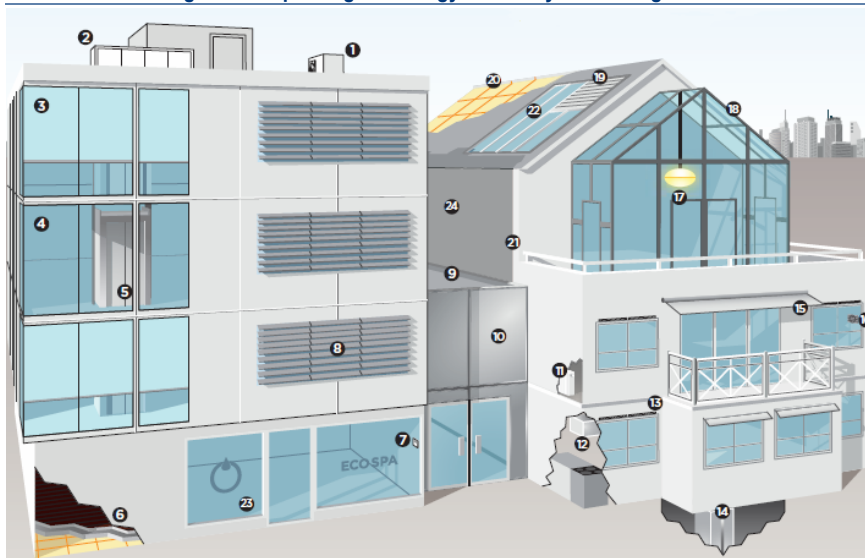
Residential and commercial buildings (including installed equipment and appliances) consumed the equivalent of 114 EJ (extrajoules) worldwide in 2005. Making use of simple energy-efficient solutions in new and existing buildings could save as much as 34% of the projected primary energy consumption by the world's buildings by 2020. This estimate would represent a reduction of 52 to 57 EJ (3.8 to 4.7bn t of CO2) by 2020 and 79 to 84 EJ (5.8 to 6.9bn t of CO2) by 2030. The potential global energy savings in buildings by 2030 are equal to the current energy consumption for all uses in Europe (source: UN Foundation).

Table 35: US energy use (in Quads)

Energy use	Quads
Residential buildings	21.3
Commercial buildings	38.8
Total building use	38.8
Total US energy use	98.3

Source: US government sources

Chart 84: Technologies for improving the energy efficiency of buildings*



Source: EuroACE. *1. Air Cooled Chiller; 2. Heat Pump; 3. Automated Roller Blind; 4. Glazing; 5. Regenerative Drive Elevator; 6. Floor Insulation; 7. Heating Controls: Room Thermostat; 8. Automated Exterior Venetian Blind; 9. Insulation; 10. Insulated Wall System; 11. Heating Controls: Radiator Thermostat; 12. Heat Recovery Ventilation; 13. Humidity Sensitive Air Inlets; 14. Heat Pump; 15. Automated Roller Blind; 16. Humidity Controlled Extract Unit; 17. Lighting; 18. Sunspace; 19. Automated Awning; 20. Insulation; 21. Sealants; 22. Roof Window; 23. Solar-control/ Low E-window Film; and 24. Air Tightness Membrane

The equivalent of 3+ mn barrels of oil could be saved each day in Europe if buildings were made more energy efficient

Lowest-hanging fruit, fast payback, huge financial benefits

The argument for energy savings is compelling and can often be achieved at low or no cost. In most cases, energy-efficient technologies for buildings make economic sense on a life-cycle cost analysis (source: IEA). Moreover, as such measures reduce dependence on fossil fuels; they also address energy security concerns. The payback is billions to trillions in financial benefits. This includes jobs with UNEP's Green Economy Report 2011 estimating that investments to improve energy efficiency in buildings could create 2-3.5mn jobs in Europe and U.S. alone.

Table 36: Financial benefits of green buildings (\$US/m²)

Category	20Y NPV
Energy value	\$62.3
Emissions value	\$12.7
Water value	\$5.5
Waste value (construction only) -1 year	\$0.3
Commissioning O&M value	\$91.2
Productivity and health value (certified and silver)	\$397.1
Productivity and health value (gold and platinum)	\$595.6
Less green cost premium	(\$43.1)
Total 20-year NPV (certified and silver)	\$526.0
Total 20-year NPV (gold and platinum)	\$724.5

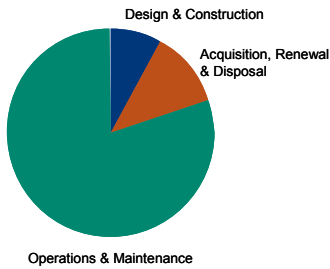
Source: Kats, BofA Merrill Lynch Global Research

Table 37: Financial benefits of energy efficiency in buildings

Estimate	Investment	Benefits
IEA	US\$2.5tn between 2010 and 2030	US\$5tn (undiscounted) in energy savings over the life of the investment
World Business Council on Sustainable Development (WBCSD)	US\$150bn/yr of green building investment in the US, EU, Japan, China, India and Brazil	Pay back the additional upfront investment in less than five years. An additional US\$150bn/yr of investment would pay back within 5-10 years
ACEEE		US could reduce energy consumption by up to 30% over the next 10-15 years by implementing efficiency measures in the residential and commercial building sector. This amount, which represents 695bn kWh p.a., could save American homes and businesses \$78bn p.a. in electricity bills
Jülich Research Centre	€1.5bn allocated in 2012, (€ 936mn in 2011) by the German State	Created an additional €5.4bn of tax receipts and €1.8bn savings in unemployment benefits. An estimated 340,000 jobs were created or safeguarded as a result
Kats		Average payback time from energy savings for green buildings of 6Y; over 20Y financial gains from reduced energy costs exceed the green premium by a factor of four to six – US\$43.1 - \$172.2 per m ²

Source: IEA, WBCSD, ACEEE, Jülich Research Centre, Kats,

Chart 85: Typical total cost of ownership (TCO)



Source: National Institute of Building Sciences

Efficiency is key to minimising TCO

Typical buildings have occupied lives of 50-75 years or longer. Operating costs usually account for 60-85% of building lifecycle costs – compared with 5-10% for design and construction costs. Implementing energy efficiency is thus key given that energy costs represent a large chunk of a commercial building’s operating costs (c.40% in the EU) and are rising faster than most other costs (source: Ingersoll Rand).

Biggest savings for newbuilds

New buildings can achieve the largest savings – with as much as 80% of the operational costs of standard new buildings saved through integrated design principles on energy efficiency, often at no or little extra cost. High-efficiency renovation or refurbishment is also an important way of reducing emissions, especially in developed markets. For instance, in Europe, which has 1bn ft² of commercial space, retrofits can enable 20-50% energy and operating cost savings (source: Ingersoll Rand) and reduce European GHG emissions by c.12% (source: EuroACE).

Efficiency is key during a recession

A recessionary environment – with a twin focus on productivity and cost reduction – amplifies the need for energy efficiency given the limited capital investments and clear paybacks.

Table 38: Near-term buildings market outlook

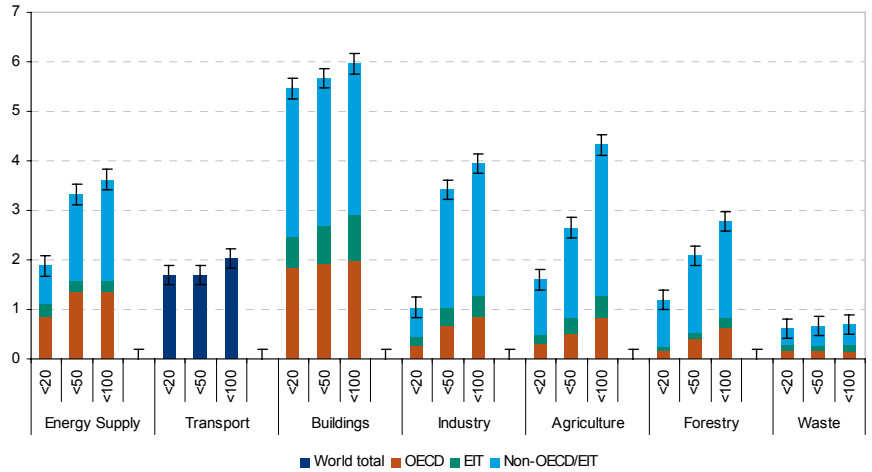
North America	Europe	Asia	Middle East & Latin Am.
Flat to minimal growth, non-residential Projected declines, institutional Positive outlook, commercial Emerging growth, residential	Western: Moderate declines, residential and non-residential Eastern: Moderate market growth	Slow, continued growth, residential and non-residential markets	UAE and Saudi lead growth in ME Brazil continues to expand

Source: Johnson Controls

Huge CO2 mitigation potential at low cost

The IEA and OECD estimate that building-sector CO2 emissions will need to be reduced from the 15.2 Gt p.a. currently projected for 2050 to approximately 2.6 Gt p.a. if the sector is to successfully meet long-term climate change goals such as the EU’s 2050 80% decarbonisation target. Efficiency offers a huge range of abatement opportunities below \$20-50/tCO2 in the building sector, which come at zero or negative cost. Acting on these will, however, require concerted action to avoid the risk of lock-in - ie, an inadequate level of renovation by pursuing only the “lowest hanging fruit” (source: EuroACE).

Chart 86: Buildings have the greatest CO2 mitigation potential to 2030 (potential at <\$100, <\$50, <\$20 per tCO2-eq)



Source: UN IPCC, BofA Merrill Lynch Global Research

c.30% reduction at zero cost

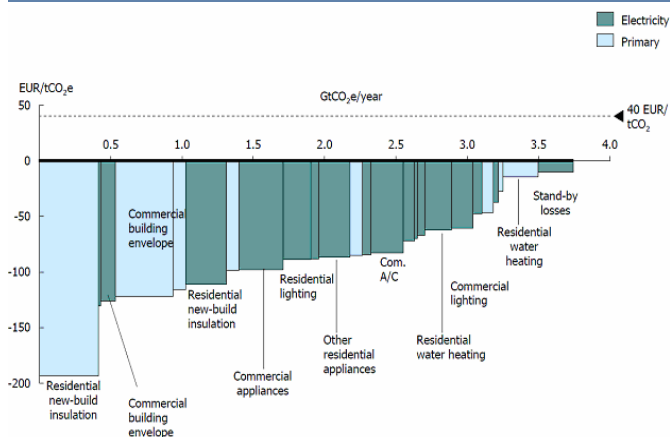
The UN IPCC analysed some 80 studies spanning 36 countries, which suggested that a 29% reduction in projected baseline CO2 emissions by 2020 was achievable at zero cost (costs below US\$0/tCO2-eq), while further improvements could be made with relatively low levels of investment. According to various estimates, an 8.2Gt to 12.6Gt reduction in building-sector emissions could be achieved by 2050 (vs 2010 levels).

Close to 500Mt of CO2 could be reduced each year in Europe alone through cost-effective energy efficiency measures in buildings. This is the equivalent of 100mn+ cars being taken off the road each year.

Low-cost mitigation potential

Buildings have the highest economic mitigation potential of any sector using technologies and practices expected to be available by 2030. The graphic below illustrates the mitigation potential expressed in GtCO2-eq/yr according to the amount that can be achieved at less than US\$20, \$50 and \$100 per tCO2-eq. Assuming a cost per tCO2-eq of no more than US\$100, the global economic mitigation potential ranges between 5.3 and 6.7 GtCO2-eq/yr by 2030 (source: UN IPCC). Note that 90% of this potential could be achieved at less than US\$20 per tCO2-eq.

Chart 87: Abatement cost curve for buildings sector 2030e



Source: BofA Merrill Lynch Global Research estimates

Chart 88: Building sector abatement opportunities & costs

	Description	Abatement potential GtCO2e	Abatement cost EUR/tCO2e
Residential			
Lighting	• Increased use of low energy light bulbs	0.2	-89
Household appliances	• Increased unit efficiency of, e.g., freezers and refrigerators	0.6	-49
Water heating	• More efficiency water heating systems	0.4	-35
A/C	• More efficient A/C systems	0.1	-48
Heating and ventilation	• Improved insulation • Change to, e.g., three-glass windows	1.2	-129
Commercial			
Lighting	• Fixtures, timers and LFLs	0.1	-61
Appliances	• More efficient office appliances	0.3	-30
Water heating	• More efficient water heating	0.1	-104
A/C	• Improved A/C systems	0.2	-83
Heating and ventilation	• Better insulation and improved heating/ventilation	0.5	-123

Source: BofA Merrill Lynch Global Research estimates

However, there are varying estimates of the annual investment needed to achieve such reductions, with the IEA and OECD projecting US\$308bn/yr to 2050 and the Peterson Institute for International Economics US\$1tn/year to 2050.

Table 39: Economics of global buildings & energy efficiency transformation

Country/region	Additional investment, 2005-50 (US\$bn/year)	NPV 2005-50	CO2 reduction* (mn tonnes 2050)	Av. abatement cost, 2005-50 (US\$/tonne)
OECD N. America	244	-46	1699	30
USA	209	-40	1555	28
OECD Europe	170	-26	915	30
OECD Pacific	67	-17	353	48
Japan	37	-9	168	52
Transition Economies	78	-12	548	24
Developing Asia	188	-26	2343	14
China	114	-15	1427	14
India	19	-2	221	12
Latin America	31	-5	148	39
Middle East	80	-17	663	32
Africa	29	-3	298	10
WORLD	1042	-180	8200	25

Source: IEA & OECD, BofA Merrill Lynch Global Research. * Relative to business as usual

Regulations & building codes driving volumes

Governments will play a critical role in promoting greater energy efficiency within the building sector and the increased use of more energy-efficient products. While manufacturers may develop innovative products, experience in most countries shows that builders and consumers need to be “persuaded” or “incentivised” to use them: this is why government legislation and building codes are vital.

Legislation is driving volumes

We remain of the view that a cyclical demand recovery will be the principal driver of revised EPS forecasts for buildings and materials companies. That said, we see additional potential upside to our forecasts and longer-term strategic attractions from energy efficiency-related legislation.

Incremental driver in tough times

Government legislation acts as a structural driver of long-term demand, but it can fail to underpin demand sufficiently during periods of cyclical contraction. It does, however, provide an incremental driver to volumes when they are recovering or growing. We believe that with little short-term technological innovation likely, the push for higher and improved efficiency standards will directly lead to a proportionate increase in the volume of efficient material used/required. For example, to achieve a 20% improvement in thermal insulation qualities requires 20% more insulation material to be used, irrespective of which sort of insulation material is specified.

The UK, US, Germany and Poland are all targeting a doubling in insulation standards between 2010 and 2016. This translates into a CAGR of c. 12%

Table 40: Overview of key building energy-efficiency policies that are currently in place by country/region and sectors

	United States	Japan	European Union	Russia	China	India	Brazil
Cross-sectoral							
Energy-efficiency strategy or target	None	None	EU Energy efficiency directive agreed; national energy efficiency action plans required; EU-level target to reduce primary energy consumption by 20% in 2020; EU ETS	2009 Federal law no. 261-FZ on energy saving and improving energy efficiency; reduce energy intensity by 40% by 2020	12th five year plan (2011-2015): target to reduce energy intensity by 16% by 2015	11th five year plan (2007-2012): target to improve energy efficiency by 20%; 12th five-year plan forthcoming	2011 national energy efficiency plan; reduce projected power consumption by 10% by 2030

Table 40: Overview of key building energy-efficiency policies that are currently in place by country/region and sectors

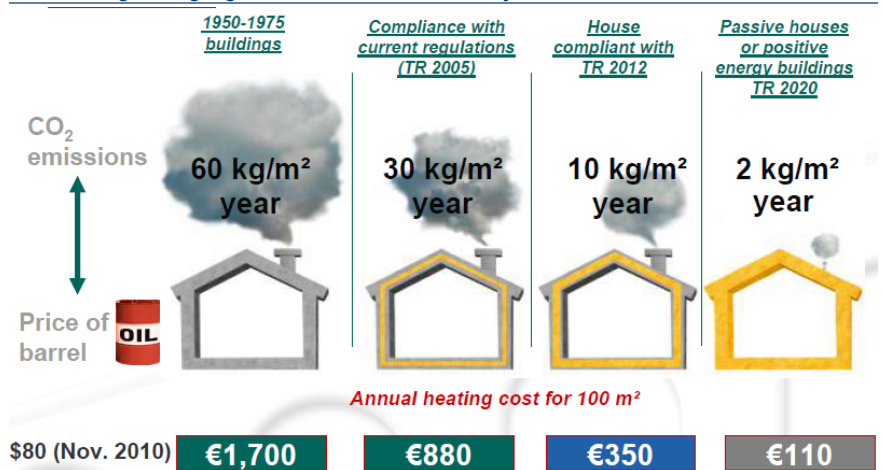
	United States	Japan	European Union	Russia	China	India	Brazil
Buildings, appliances, equipment and lighting							
Building energy performance requirements	Mandatory energy requirements in building codes in some states	Voluntary guidelines in place	Building energy performance requirements for new buildings (zero-energy buildings by 2021) and for existing buildings when extensively renovated; 3% renovation rate of central government buildings	Mandatory building codes (but not yet fully implemented)	Mandatory codes for all new large residential buildings in big cities	Energy conservation building code (2007), with voluntary requirements for commercial and residential buildings	Voluntary guidelines in place
Energy labelling	Voluntary buildings labelling; mandatory and voluntary labelling for some appliances and equipment	Voluntary buildings labelling; national voluntary equipment labelling programmes	Labelling mandatory for sale or rental of all buildings and some appliances, lighting and equipment	Information on energy efficiency classes for appliances required since January 2011	Labelling mandatory for new, large commercial and governmental buildings in big cities	Voluntary star ratings for office buildings	Voluntary for residential and commercial buildings
Equipment energy performance requirements	45 products covered	Top runner: 23 products covered	15 product groups in EcoDesign directive, further product groups planned end-2012; phase-out of incandescent light bulbs	Phase-out of incandescent >100 watt light bulbs	46 products covered by labelling schemes	Mandatory S&L for room air conditioners and refrigerators, voluntary for five other products	13 products covered by voluntary labels

Source: IEA World Energy Outlook 2012

EU has taken the lead

The EU has taken a strong lead on tightening building codes over the past decade, with long-term goals (by 2020) of cutting emissions by 29% for residential buildings and 13% for commercial (vs 2008 baseline), reducing the EU's "energy bill" by about €200bn/year, lowering energy dependence and capex investments in energy infrastructure, and creating up to 2mn new jobs (source: EC).

Chart 89: Tightening regulations on thermal efficiency



Source: Saint-Gobain

EPBD & nearly zero energy buildings

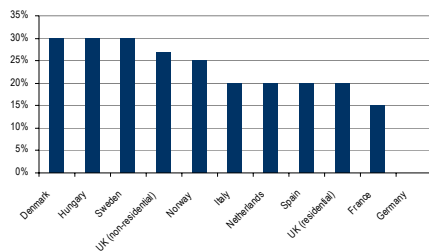
The Energy Performance of Buildings Directive (EPBD) – which was introduced in 2002 and recast in 2010 – requires Member States to set minimum energy performance requirements for buildings:

Individual goals are set by member states and a number of countries have already anticipated the new regulations:

- France: energy-positive buildings by 2020
- Netherlands: energy-neutral buildings by 2020
- UK: zero-carbon homes by 2016 (heating & lighting)

Various paths are being followed in different countries with the UK focusing on energy suppliers, and France, Germany, and Scandinavia stimulating building owners with direct subsidies

Chart 90: Potential energy reductions in new buildings: 2009 targets



Source: EC. Sweden- electrically-heated buildings only; Netherlands- Residential only.

- **Nearly zero energy buildings:** From 2020, all new buildings in the EU will have to be 'passive', ie, "nearly zero energy buildings that comply with high energy-performance standards. This is defined as: "a building that has a very high energy performance (covering all energy uses, expressed in primary energy use) and the nearly zero or very low amount of energy required should to a very significant level be covered by energy from a renewable source including RES onsite and nearby" (source: EU). For buildings owned and occupied by public authorities, these standards need to be met by the end of 2018. Intermediate targets are to be set by 2015. Apart from the 'nearly zero-energy' target, which must be met by 2020, governments had to adopt regulations and procedures for the other requirements by July 2012, and implement them between then and January 2013.
- **Minimum energy requirements for renovations** covering building components like walls, roofs, windows, etc., applied every time these components are introduced or replaced.
- **For existing buildings**, member states shall follow the leading example of the public sector, develop policies and take measures, such as setting targets, to stimulate the transformation of buildings that are refurbished into very low-energy buildings, and inform the Commission thereof in their national plans.
- **Ensure that an Energy Performance Certificate** is issued when buildings are constructed, sold or rented out. The EPCs need to be included as part of the advertising for sale or rent, displayed for buildings of 500 m²+, and for 250 m²+ by 2015.

The first new national Building Codes following the EPBD came into effect in 2006 and there has been a correspondingly positive impact on the energy efficiency of new buildings in many member states. In the most proactive countries, this has led to a tightening of their energy performance demands for new buildings by some 25% to 30% to date.

Energy Efficiency Directive (EED) adopted in 2012

In October 2012, the European Council approved an Energy Efficiency Directive which will require energy-savings schemes for utilities, energy audits for all large companies and renovation of public buildings. After it entered into force in November 2012, member states have 18 months to incorporate it into national law:

- **Energy companies will have to achieve a "cumulative end-use energy savings target" by 2020.** This target will have to be at least equivalent to achieving new savings, each year from 2014 to 2020, of 1.5% of annual energy sales to final customers, by volume, and averaged over the most recent three-year period before the directive takes effect. Sales of energy used in transport will be excluded and alternative ways to achieve equivalent energy savings will be permitted, provided that equivalence is maintained.
- **All large companies will be required to undergo an energy audit.** These audits will need to start within three years of the directive's coming into force and should be carried out every four years by qualified and accredited experts. SMEs are excluded from this obligation.

“Upgrading the energy efficiency of America’s buildings is one of the fastest, easiest, and cheapest ways to save money, cut down on harmful pollution, and create good jobs right now. But we can’t wait for Congress to act” US President Obama

New York City estimates 75% of the city’s CO2 emissions stem from energy used in buildings - and today’s buildings will still make up 85% of the real estate in 2030

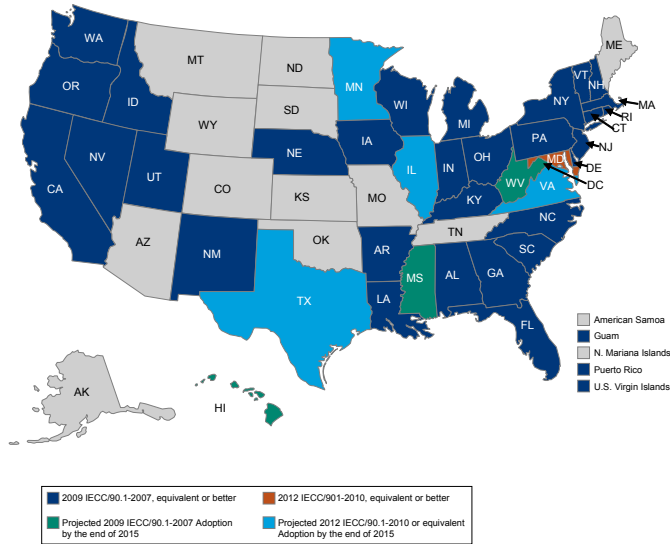
Renovation of 3% of public buildings. The directive will require member states to renovate 3% of the total floor area of "heated and/or cooled buildings owned and occupied by their central government" (administrative departments whose responsibilities cover the entire territory of a member state). This will apply to buildings with a "total useful floor area" of more than 500 m², and as from July 2015, of more than 250 m². However, member states will also be able to use alternative means to achieve equivalent energy savings (source: European Commission).

US finally making some progress

As far as energy-efficient building codes are concerned, the US has long been a laggard compared with the EU, CEE, Russia, Japan, South Africa and parts of Latin America. However, despite the recession, the past three years have seen a number of positive signals including the American Jobs Act, Obama’s Better Building Challenge, Executive Order 13514, concerted action at state and city level, and the first national green building code. We believe that we could see further action when the economy settles down.

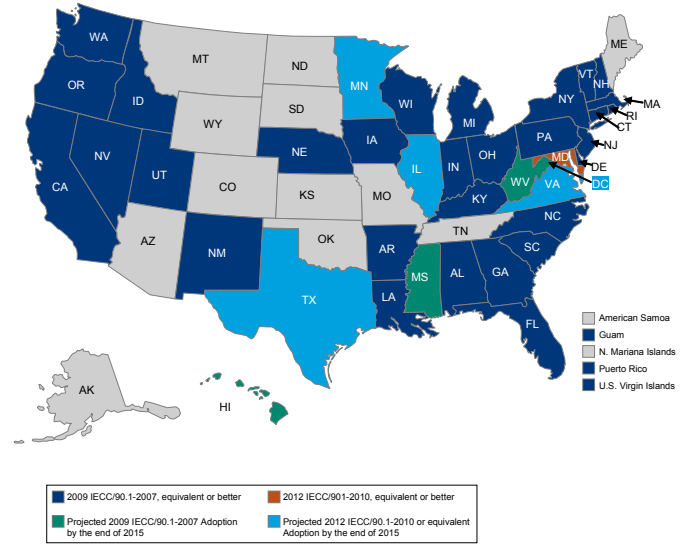
- **American Jobs Act:** Repair or modernize 35,000 public schools.
- **“Better Buildings Initiative”:** The plan proposed by President Obama aims to improve the energy efficiency of commercial buildings by 20% by 2020. Several proposals were made in the DOE’s FY 2012 budget to make the existing 179D tax deduction for commercial buildings more robust and usable; a request to provide loan guarantees for energy-efficiency retrofits at universities, hospitals and commercial buildings; and a Small Business Administration (SBA) initiative to encourage the use of SBA loans for small business energy efficiency retrofits.
- **Federal Executive Order 13514** (Federal Leadership in Environmental, Energy, and Economic Performance), - starting in 2020, all new Federal buildings must achieve net-zero energy by 2030.
- **States are getting serious** and are increasingly adopting model codes for residential and commercial buildings. Some 42 states have adopted state-wide building energy codes. Codes are also becoming more stringent with the 2012 model IECC (International Energy Conservation Code), 30% more efficient than the 2006 code (source: US DOE). At least 10 states are also currently developing laws that would require energy rating and disclosure.

Chart 91: Projected commercial building energy code adoption activity



Source: US DOE, BofA Merrill Lynch Global Research. Data as of December 2012.

Chart 92: Projected residential building energy code adoption activity



Source: US DOE, BofA Merrill Lynch Global Research. Data as of December 2012.

- Cities are taking the lead with New York, Seattle, San Francisco, Boston, Washington and Philadelphia, among others, requiring building owners to report “building energy use intensity” – and some requiring the information to be given to buyers, lessees, or lenders and/or additional information to meet audit requirements.

Table 41: EPA Energy Star US Cities Top 10 ranked

2012 Rank	Metro area	Energy Star Certified Buildings in 2012	Total Floorspace (million sq. ft.)	Annual cost savings (millions)	Emissions prevented (Equal to _____ Homes annual electric use)	2011 Rank	2010 Rank	2009 Rank	2008 Rank
1	Los Angeles	528	112.5	\$134.8	52,300	1	1	1	1
	Washington,								
2	DC	462	116.1	\$127.4	83,100	2	2	2	4
3	Chicago	353	130.4	\$92.3	118,400	4	4	5	6
4	New York	325	111.5	\$144.6	63,600	6	5	10	12
5	Atlanta	304	63.6	\$52.3	55,500	3	6	9	9
	San								
6	Francisco	291	70.1	\$106.5	39,300	5	3	3	2
7	Houston	241	88.6	\$73.8	72,900	7	7	6	3
	Dallas-Fort								
8	Worth	214	59	\$47.3	48,400	8	10	8	5
9	Phoenix	202	31.6	\$34.4	32,500	13	17	20	22
10	Boston	188	45.5	\$67.5	25,000	10	12	13	11

Source: rtcc.org, BofA Merrill Lynch Global Research

“It (IGCC) represents a change in the standard of construction. It will affect everyone that touches buildings...it will be a big leap.” - Director of Sustainability Advocacy at the American Institute of Architects

- **IgCC, 1st national green building code:** The International Green Construction Code (IgCC) was published in March 2012 and is the first US model code to establish baseline regulations relating to energy efficiency for new and existing buildings. The code applies to all new and renovated commercial buildings and residential buildings over three storeys. A number of local and state governments have already adopted it (Maryland, Oregon, Rhode Island, Phoenix et. al.) – and, in time, it is likely to be absorbed into industry standards. The objective of the code is to improve energy efficiency, reduce waste and improve health.

Table 42: Efficiency provisions of the International Green Construction Code

EE provision	Overview
Site Development, Land Use	Restricts development on greenfields (undeveloped land), although there are exceptions based on existing infrastructure. It includes clear guidelines for site disturbance, irrigation, erosion control, transportation, heat island mitigation, graywater systems, habitat protection, and site restoration.
Materials	A minimum of 50% of construction waste must be diverted from landfills, and at least 55% of building materials must be salvaged, recycled-content, recyclable, bio-based, or indigenous. Buildings must be designed for at least 60 years of life, and must have a service plan that justifies that.
Energy Efficiency	Total efficiency must be "51% of the energy allowable in the 2000 International Energy Conservation Code" (IECC), and building envelope performance must exceed that by 10%. It sets minimum standards for lighting and mechanical systems, and requires certain levels of sub-metering and demand-response automation.
Water Efficiency	Establishes maximum consumption of fixtures and appliances and sets standards for rainwater storage and graywater systems.
Indoor Air Quality	Addresses radon, asbestos, VOCs, sound transmission, and daylighting.
Commissioning, Operations	Requires extensive pre- and post-occupancy commissioning and education of building owners and maintenance employees.
Additional Elective	Every project is also required to choose an additional "elective," which pushes the envelope for the developer further. Once they choose it, it's enforceable. There's a long menu of elective choices, including whole-building life-cycle assessment to more stringent recycled content.

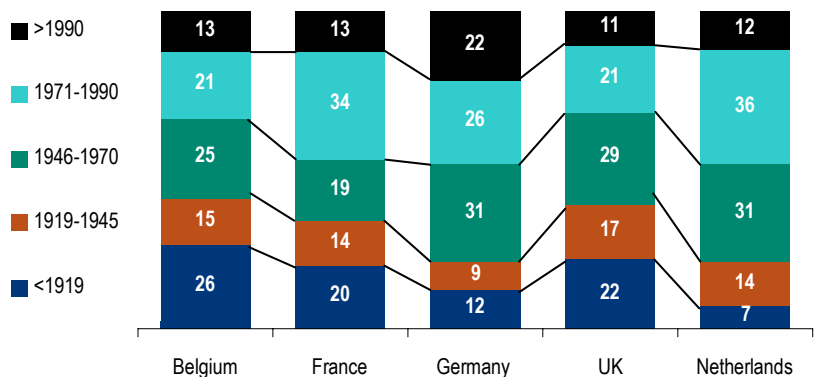
Source: BofA Merrill Lynch Global Research estimates

Home improvement upgrades: "Renovation Nation"

One of the biggest global challenges on efficiency in buildings is rising electricity consumption and the fact that new construction represents less than 2% of existing building stock. The refurbishment of existing building stock and improvements in energy management are thus vital to meet emission-reduction targets. At the very least, we need to see renovation of 10% per year of existing stock to achieve a 20% reduction in energy consumption. While it is early days, we are starting to see positive signs in the US, as illustrated by our US Hardline Retail team's "Renovation Nation" work.

[Retailing - Hardlines, 04 April 2012](#)

Chart 93: Relative age of building stock in select EU countries (% of housing stock by year of construction)



Source: Global Energy Reduction Fund, BofA Merrill Lynch Global Research

Energy efficiency as a driver for residential demand

Energy efficiency and distributed energy generation are emerging as significant sources of residential improvement demand. The availability of improving technology in lighting, building insulation and windows offers homeowners the potential to reduce monthly heating and lighting bills, sometimes with tax incentives as an added boost. Declining natural gas prices notwithstanding, retail electricity rates have been slow to drop.

“Renovation Generation” to drive medium-long term growth in home improvement

Older homes require more maintenance

The median age of the housing stock is at a multi-year high of 35 years based on 2009 American Housing Survey data. From 1997-2007, the median age of the housing stock rose by three years from 29 to 32 years, and from 2007-2009 it increased by another three years. Given the dearth of new housing starts in the past two years, we estimate that the median age has risen further to approximately 39 years. Moreover, the recession and housing bust of the past few years was probably responsible for a significant amount of underinvestment in regular maintenance, which would imply pent-up demand for home improvement.

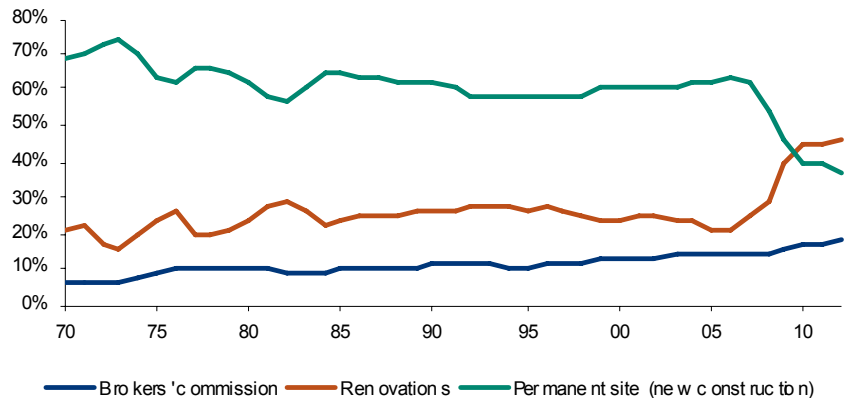
Home improvement, an upper-middle income skew

The home improvement market largely bottomed out in 2009/10 after three years of declines and increased modestly in 2011. Industry demand levels remain well below their peaks largely due to a fall-off in demand from both new construction and housing turnover as well as depressed levels of repair and maintenance. Not surprisingly, we think that spending on home energy efficiency is likely to be skewed towards upper-income households, not only because of available resources but also because larger homes tend to have bigger utility bills. We model 10% penetration by 2015 for households with US\$100,000 or more in annual income, twice our assumption for households between US\$50,000 and US\$100,000, and we assume no penetration at all for households below US\$50,000. The result works out to an estimated US\$20bn in activity during 2012. New movers spend 25% more on projects.

Housing turnover is key to DIY demand

Housing turnover remains as critical a driver for home improvement demand as ever. Based on the 2009 American Housing Survey, we also note that out of total household projects, DIY rates were 39% for the total population, 29% for African Americans, 47% for Hispanics, 24% for the elderly, 42% for those below the poverty level and 38% for people who moved in the last year. The median project cost was US\$2,700, with the elderly spending US\$2,800 (probably because they rely more on contractors) and US\$2,000 for all other groups except those that moved in the last year (US\$2,500). Put another way, new movers spend 25% more on home improvement projects than all other demographic groups except the elderly, who are more reliant on contractors.

Chart 94: Renovation spending increasing as a share of residential investment (% res inv)



Source: BofA Merrill Lynch Global Research, BEA

[Housing Watch, 11 December 2012](#)

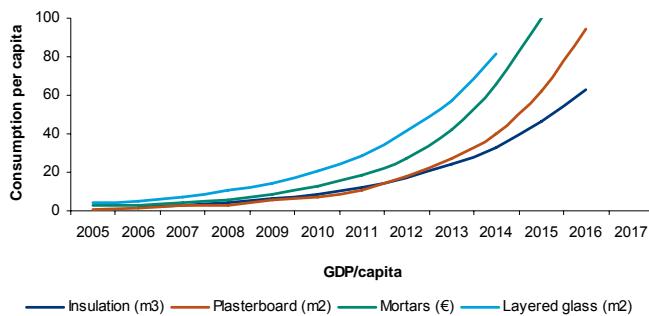
US housing continues to recover

We believe the US housing recovery will continue into 2013 for several reasons. Most importantly, household formation has started to increase, reflecting the shortfall of household creation over the prior five years. Moreover, investor demand is strong, particularly for distressed inventory. We forecast housing starts to increase by another 25% to an average of 975,000 and home prices to grow by 3% in 2013. The health of the broader economy, credit conditions and policy changes can influence this forecast in either direction. On the upside, a stronger rebound in economic growth would generate more jobs, thereby spurring faster household formation. Similarly, an easing in credit conditions would allow for a broader base of buyers. Finally, we have seen positive policy decisions, such as clarification on the rules of mortgage lending, more lenient refinancing and modification efforts.

Solid long-term growth drivers

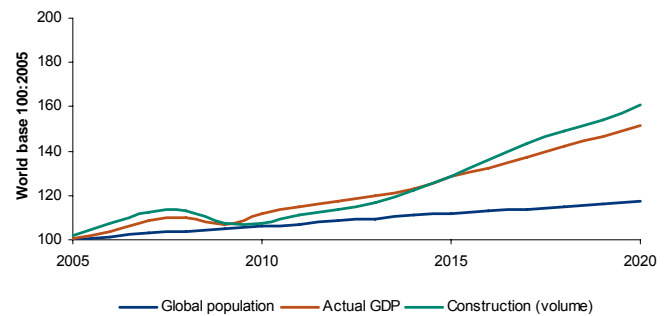
In addition to the huge energy, cost-saving and CO2 reduction potential, we believe that increasing energy efficiency in buildings will be supported by a series of long-term drivers described below.

Chart 95: Increasing focus on value-added efficiency solutions



Source: Saint Gobain, BofA Merrill Lynch Global Research

Chart 96: Fast-growing markets

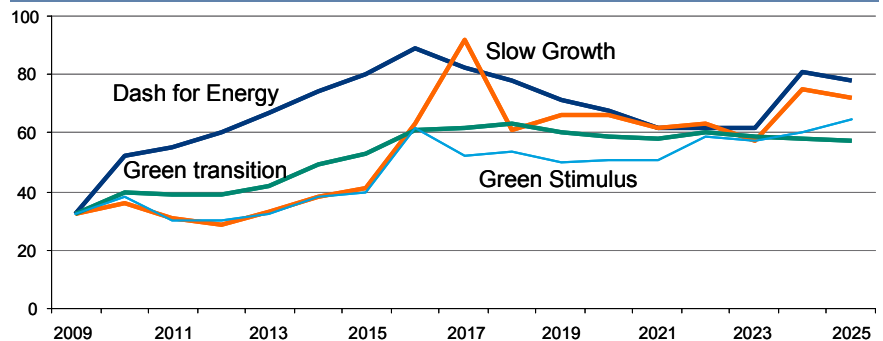


Source: Saint Gobain, BofA Merrill Lynch Global Research

In the UK, average electricity prices have increased by 65% over the past 10Y. Ofgem's Project Discovery modelled four future energy use scenarios, all of which predict the wholesale electricity price will more than double between 2009 and 2016

- **Energy costs:** 20-40% energy savings are available on existing buildings over five years old (ie, favourable NAV).
- **Energy prices to rise:** energy prices are expected to increase across the globe over the long term, driving energy efficiency in renovations.
- **Demand for power set to increase** – see above.

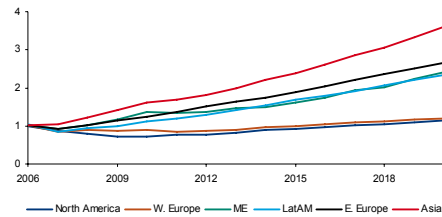
Chart 97: Wholesale electricity prices



Source: Ofgem: Project Discovery – four energy use scenarios, BofA Merrill Lynch Global Research

In the UK, 25% of UK power stations will close over the next decade - the replacement cost = £110bn. Demand for electricity is expected to double within 40 years (source: Ingersoll Rand)

Chart 98: Global Non-Residential Construction Indexed to 2008



Source: Johnson Controls, BofA Merrill Lynch Global Research

- **Energy security** is promoted as the demand for imported energy is reduced
- **Climate legislation**: there are close to 60 countries worldwide with pending or approved carbon reduction mandates that affect buildings.
- **CO2 emissions**: emissions from buildings will grow by 50+% by 2030E, the bulk of which from North America and Asia (source: IPCC).
- **Emerging markets growth**: over the next 10 years, over 110 billion additional square feet of commercial space will be built (vs c.400bn ft² of global space today), 80%+ of which will be in emerging markets (source: Johnson Controls). Electricity consumption often outpaces economic growth as living standards and demand for AC rise.

Table 43: Expected construction growth 2011-15

Region	Construction growth 2011-15e
Asia	11%
Middle East	11%
Latin America	10%
Eastern Europe	10%
North America	9%
Western Europe	4%

Source: Johnson Controls, BofA Merrill Lynch Global Research

- **Urbanisation in emerging markets**: 50% of the world's population currently lives in urban areas. This will grow to 70% by 2030. Over 90% of urban growth will be in emerging markets (source: UN).

Table 44: Major opportunities for green buildings

	Retrofits	Newbuilds
Developed markets	<i>KEY FOCUS</i> <ul style="list-style-type: none"> •Single homes that lack efficiency norms (EU) Homes to increase lifespan (Japan) 	<i>SECONDARY FOCUS</i> <ul style="list-style-type: none"> •New construction in US & Japan •New green standards
Emerging markets	<i>SECONDARY FOCUS</i> <ul style="list-style-type: none"> •Single homes needing retrofits to meet basic sustenance levels (electricity etc.); built by the informal sector to meet basic efficiency standards •Multi-family homes 	<i>KEY FOCUS</i> <ul style="list-style-type: none"> •Huge housing shortages and greening publicly subsidised and privately financed housing •Huge demand for office space and greening via corporate demand

Source: WBCSD, BofA Merrill Lynch Global Research

- **Green premium**: high-performance green buildings command higher rents (up to 6% in terms of effective rents according to many estimates), enjoy higher occupancy rates, and sell for more on the market.
- **New build rates**: these are driven by demographics, M2 per inhabitant, macroeconomics and urbanisation.
- **Corporate commitments**: 51% of the "global 500" have publicly disclosed GHG reduction goals – of these, the majority identify energy efficiency of their buildings as a priority.
- **Affordable and sustainable housing**: this is a priority for many emerging and developed market governments.
- **Reduces fuel poverty**: rising energy costs are leading to fuel poverty in certain developed markets and pushing governments to invest in EE as a means of controlling the issue (ie, reducing the cost for the poor to heat their homes).

In the UK, where fuel poverty is defined as spending >10% of household income on energy, Government figures show c.4.5mn fuel-poor households, double 5Y ago

Energy efficiency loan defaults of 0-3% compare favourably with residential mortgage default rates of 5.67%, credit card default rates of 9.14%, and even car loan defaults at 1.94%

- **Low financing risk:** energy efficiency financing programmes are thought to have low default rates, with one recent US study of 24 EE loan programmes finding default rates of only 0-3%, with rates holding fast since the housing bubble (source: The American Council for an Energy Efficient Economy)
- **Economic importance of the sector:** in the EU, for instance, the building sector accounts for 9% of EU27 GDP, 8% of employment and c.€2tn of annual turnover. Investing in building renovation could accrue up to €175 billion per year for public finances with an additional “one-off” boost to GDP in the range of €153 to €291 billion for the years up to and including 2017 as per a report prepared by Copenhagen Economics for the Renovate Europe Campaign.
- **Job creation:** the economic growth potential of buildings is often neglected – with estimates that large-scale renovation could create up to 530,000 jobs in Europe and 1.1 million in the US (source Renovate Europe, Rocky Mountain Institute).
- **Long-termism:** newbuilds rarely replace old buildings – they just add to the building stock. For instance, an estimated 50% of the c.210mn buildings in the EU were built before the first global oil crisis in 1973 and only 0.1% of buildings are demolished each year (vs a newbuild rate of 1%). Globally, industry estimates that 65% of buildings that exist today will still be in use in 2050.

Table 45: Building efficiency factors across major regions

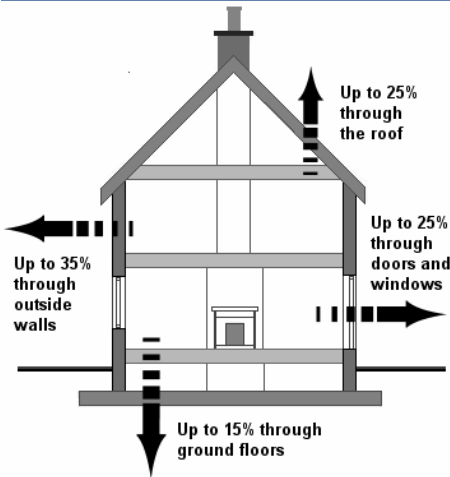
Region / country	Overview
Western Europe	<ul style="list-style-type: none"> • New build rate going forward will move up but only to a moderate level due to slow demographic movement/increased urbanisation • Aggressive tightening of building codes will multiply insulation volumes per square metre • Stimulus packages are short-term a solid foundation in key markets • Rising energy prices to be passed on to building owners - high level of energy taxes • Consolidation potential very low
Central & Eastern Europe	<ul style="list-style-type: none"> • New build is at an absolute low point but will move up to reflect low level of m2 per inhabitant • Aggressive tightening of new build codes exception • Renovation need substantial but no subsidy programmes to support market forces • Effect of rising energy prices strengthened by elimination of subsidies and individual metering of consumption • Consolidation possibilities low
Russia	<ul style="list-style-type: none"> • New build rates are moving up and are expected to stay reasonable due to increased urbanisation and higher no. of m2 per inhabitant • Tightening of building codes ongoing • Strong subsidies to bring down very high energy consumption in existing buildings; public finances benefit from high energy prices • High energy prices increasingly passed on to final consumer and increased use of individual metering • Consolidation potential reasonable
North America	<ul style="list-style-type: none"> • The newbuild rate will (post-crisis) be lifted by demographics • New build standards expected to be lifted substantially but major legislative framework not in place • Subsidy programmes expected • Energy prices for final consumer still substantially lower than in the EU • Consolidation potential low
Asia	<ul style="list-style-type: none"> • Fastest growing construction market in the world fuelled by strong macro-economics, urbanisation & need for more m2 per inhabitant • Legislation: insulation is applied in Northern regions (China) but is more or less absent in Southern regions where AC is growing fast • Insulation of infrastructure (power plants, industrial processes) growing fast • Limited or no renovation activity • Consolidation potential high

Source: Rockwool, BofA Merrill Lynch Global Research

Building envelope & efficiency opportunities

We see significant value arising from energy efficiency in new construction and building retrofits. This growth will take different forms with developed countries having higher potential for green refurbishment and retrofits and emerging markets focused on efficiency in new construction.

Chart 99: Heat loss from poor thermal envelope



Source: Low Energy House

Effective thermal envelope is key, 2-4x improvements

An effective thermal envelope is the key to energy efficiency in buildings. A thermal envelope refers to the ability of the shell of a building to act as a barrier to heat transfer between its interior and exterior. Its effectiveness is a function of three factors: 1) insulation levels (walls, ceiling/roof, ground/basement); 2) windows and doors; and 3) the rate of inside and outside air and air tightness of the building envelope (HVAC).

It is estimated that 40% of the EU's total energy consumption is from buildings, with an estimated €270bn lost because of poor energy efficiency every year (source: EC). Improvements in the thermal envelope can, for instance, reduce heating requirements by up to 2-4x, as well as lower summer cooling energy use (source: UN IPCC). Up to 78% of the energy used in buildings can be saved through thermal renovation – and simple measures around windows and insulation (source: Saint-Gobain).

Table 46: Efficiency gains from thermal envelope

Technology	Energy savings	Cost	Overview	Barriers
Building airtightness	10-40% of HVAC	Low	Reduce energy loss through unintentional air leakage via the building envelope; retrofits possible	Lack of understanding of cost & impact, poor construction practices, lack of regulations
Cool roofing	6-16% of cooling energy	Low to Med	Coatings w/ high solar resistance reflect heat, transfer less heat to buildings	Aesthetics (white coatings), limited life cycle (degradation), lack of regulations
Electrochromic windows	<19-26% of cooling loads, <45-65% of lighting energy	High	Adjust light transmission properties of glazing to minimise solar heat gain & maximise natural lighting	High initial cost: incremental costs are US\$1000/m ² (\$93/ft ²) of glazing
High performance windows	39% of heating & 32% of cooling energy	Med.	2 nd gen low-e coatings, high insulation technologies w/ triple or quadruple panes, vacuum spaces & aerogels, retrofits possible	High initial cost: US\$30-50/m ² higher than standard
Improved insulation	12%	Low	Improved insulation products or practices to avoid loss of thermal insulation R-values, thermal bridging & air leakage	Lack of consumer & builder education, could be expensive

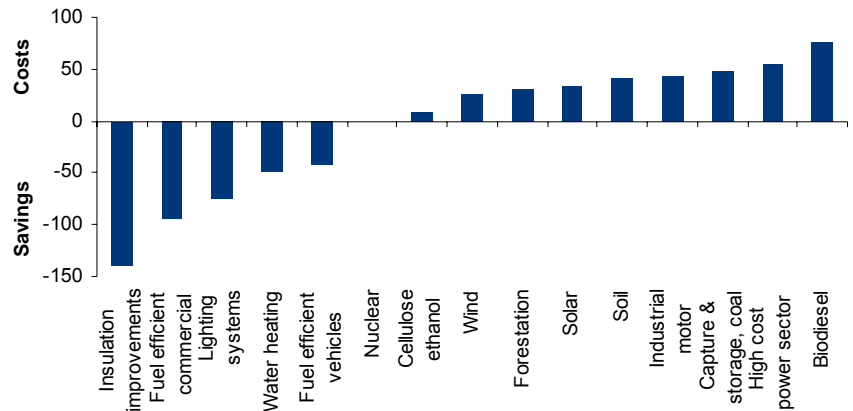
Source: Industry, BofA Merrill Lynch Global Research

Globally, insulation of buildings saves 2.4 GtCO₂e. Assuming best-in-class insulation standards were applied globally, the abatement potential could grow another 1.7Gt CO₂e by 2030 (source: Vattenfall)

1) Insulation

Thermal insulation reduces heat loss or gain by providing a barrier between areas that are different in temperature. It is used for walls, roofs, boilers and hot water pipes and plays the largest role in maximising the long-term thermal performance of buildings, by keeping cold out in winter months and preventing heat from entering during summer months.

Chart 100: Insulation is the easiest and cheapest way to reduce CO2 emissions



Source: Rockwool, McKinsey

Reduced energy consumption, costs & emissions

High-performance insulation significantly reduces energy consumption, costs and GHG emissions. In the US, for instance, all insulation products installed in buildings save consumers about 12 quadrillion BTUs annually or about 42% of the energy that would have been consumed with no insulation in place (source: Source: Saint-Gobain); they also reduce US CO2 emissions by 780Mt/y. Importantly, there is huge room for improvement – in the US it is estimated that up to 60% of homes are under-insulated and that up to 50% of the energy in buildings is lost due to inadequate insulation (source: Saint-Gobain).

Table 47: Insulation types

Insulation	Overview
Glass wool	Most popular and widely used insulation material Made from recycled glass bottles (eco-friendly), easy to handle and install, cost-effective
Mineral wool	Solid structure makes it ideal for situations where it may be under compression, (eg, on a flat roof).
Foam	Rigid foam insulation (eg, EPS (expanded polystyrene) and XPS (extruded polystyrene) has high compressive strength and is usually used where it needs to support weight (eg, under a floor, or in lofts as a storage solution). Also provides fire resistance and acoustic insulation

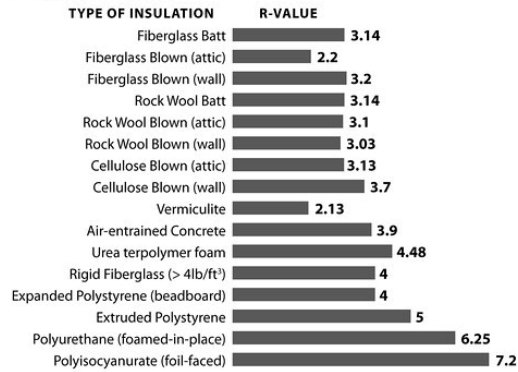
Source: BofA Merrill Lynch Global Research

Fiberglass is well suited for single family homes given its durability and resistance to moisture.

The R-factor – a measure of thermal resistance – can be used to evaluate different types of insulation: the higher the R-factor, the more energy-efficient the insulation.

Chart 101: Insulation R-Values

Insulation R-Values



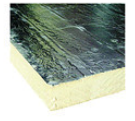
3.14
Fiberglass Batt



3.13
Cellulose Blown (attic)



6.25
Polyurethane (foamed-in-place)



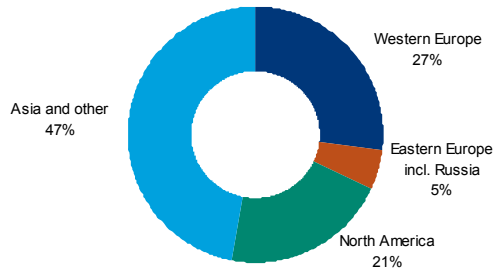
7.2
Polyisocyanurate (foil-faced)

Source: National Energy Education Development Project

US\$17bn+ global market

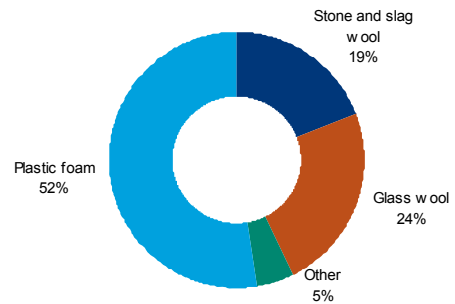
The European, North American, Chinese and South East Asian insulation markets are currently estimated to be worth over €13bn/year, with Europe being the biggest (€6.5bn), North America (€4.1bn) coming a close second, and China and South East Asia increasingly gaining in importance. Global insulation consumption is forecast to grow by more than 5% annually to approximately 29 billion square meters of R-1 value in 2016 driven primarily by building construction, of which c.65% will be from the Asia Pacific region (Source Rockwool)

Chart 102: World insulation market 2012 by region



Source: Rockwool, BofA Merrill Lynch Global Research

Chart 103: World insulation market 2012 by product



Source: Rockwool, BofA Merrill Lynch Global Research

Homebuilders and Building Products, 10 January 2013

Newbuild & renovation key drivers

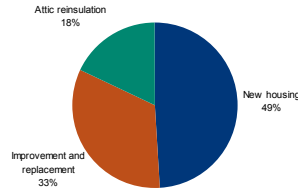
New residential construction, remodelling and repair activities are key drivers for insulation demand. Generally, insulation demand tends to lag new residential construction by three months. Also, as the peak season for US housing construction occurs during the second and third quarters, demand for insulation tends to be greater in the second half of the year. Commercial and industrial construction activity and increasingly stringent building codes can also affect insulation demand. Improvements in energy efficiency in both residential and commercial markets will also drive demand.

Chart 104: Insulation demand by product (US\$m)



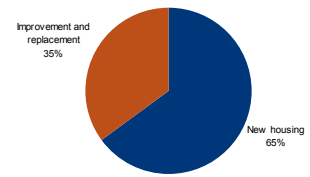
Source: Freedonia

Chart 105: Residential construction market for insulation by application



Source: The Freedonia Group. Figures do not add to 100% due to rounding.

Chart 106: Non-residential construction market for insulation by application



Source: The Freedonia Group

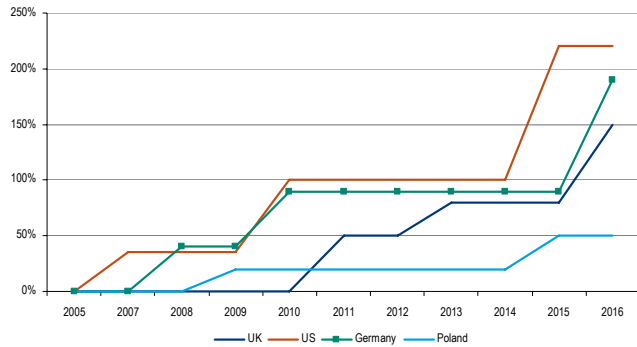
Costs driving regulation

With oil prices flirting around US\$100 a barrel, cost is driving many jurisdictions to regulate more efficient insulation. For instance, in the US there are an estimated 60 million under-insulated homes that face energy costs of up to 47% higher this winter. Such homes emit 0.5t more CO2 each year than their properly insulated neighbours (source: Owens-Corning).

Efficiency still a driver during the recession

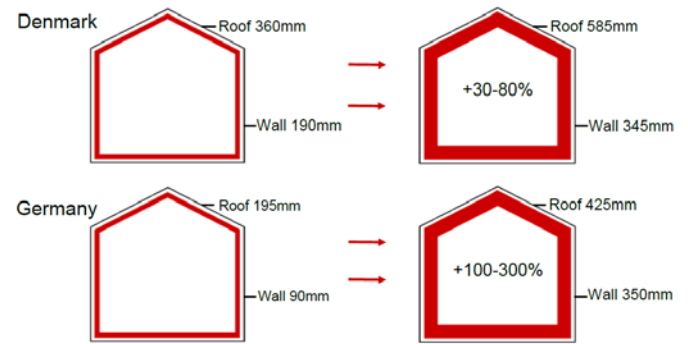
In Europe, we are seeing a market recovery led by France (cf. Grenelle de l'Environnement) and Germany (cf. government efficiency programmes including doubling the renovation target to 2% and €1.5bn in funding for 2012), and positive trends in the Nordics. Meanwhile, the Dutch, Spanish and UK markets remain challenging. In North America, insulation sales are growing despite a weak housing market, with a strong state focus on efficiency (source: Kingspan, Rockwool).

Chart 107: Percentage improvement in insulation standards from 2005



Source: EU, BofA Merrill Lynch Global Research estimates

Chart 108: Tightening of new build codes aimed at passive houses by 2018-20



Source: Rockwool

Chart 109: Energy savings & GHG abatement in US by adding exterior R-4 insulation in a single family home

Energy Savings Provided by Adding Exterior R-4 EPS Insulation in a Single Family Home

The added efficiency from installing R-4 EPS insulation saves 6.58 million BTU's each year in the average U.S. home.

ENERGY INVESTMENT	MILLIONS BTU's
EPS Production	8.90
EPS Transportation	0.13
Total Energy Invested	9.03

ENERGY SAVINGS (millions of BTU's)	ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5	U.S. AVG.
Annual Energy Savings	11.37	9.58	7.84	5.58	5	6.58
Payback Period (years)	0.79	0.94	1.15	1.62	1.81	1.37
Savings Over 50 Years	568	479	392	279	250	329

Global Warming Potential Reductions Provided by Adding Exterior R-4 EPS Insulation in a Single Family Home

The added efficiency from installing R-4 EPS insulation saves 982 pounds of carbon dioxide from being emitted each year in the average U.S. home.

GLOBAL WARMING POTENTIAL INVESTMENT	LBS. CO ₂ EQUIV.
EPS Production	8.90
EPS Transportation	0.13
Total Energy Invested	9.03

GLOBAL WARMING REDUCTIONS (compared to base wall)	ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5	U.S. AVG.
Annual Reductions (lbs. CO ₂)	1,669	1,354	1,155	831	777	982
Payback Period (years)	0.49	0.61	0.71	0.99	1.05	0.83
Savings Over 50 Years	83,473	67,682	57,739	41,257	38,867	49,095

Source: Chemistry and Energy Efficiency

High R-values mean lower costs & rapid paybacks

The payback periods for insulation will vary widely according to climate (warm, moderate or cold), how much insulation is already present, the size of the building, the number of external walls, and the fuel used to heat or cool the property. Regardless, there is still a substantial ROI from investing in high R-value insulation:

- North American paybacks are no greater than two years (for R-6 insulation in zone 5) and can be as little as three months (for R-4 insulation in the Northwest Territories of Canada) (source: EPS Molders). We also note that insulation is one of only a few products which save more energy over a lifetime than is used for their production.

Table 48: North American & emerging market insulation market overview

Market	Attributes	Growth drivers
North America residential new construction	<ul style="list-style-type: none"> Cyclical business Multiple distribution channels Strong contractor customer base 	<ul style="list-style-type: none"> Housing starts Building energy code adaptation Household formation
North America residential repair & remodel	<ul style="list-style-type: none"> Diverse contractor & DIY customer base Project focused Big box retail 	<ul style="list-style-type: none"> Ageing housing stock Energy efficiency policies Existing home sales
North America commercial & industrial	<ul style="list-style-type: none"> Broad end-market applications Engineered product solutions Total building system focused 	<ul style="list-style-type: none"> Code & green specification driven Owner operator focus Accessible financing
Emerging markets	<ul style="list-style-type: none"> Strong long-term economic growth Emerging building code development 	<ul style="list-style-type: none"> Growing middle class Infrastructure improvements Urbanisation of China

Source: Johnson Controls, BofA Merrill Lynch Global Research

- UK paybacks are no greater than two years for loft insulation while cavity and wall insulation offer greater savings (although they require professional installation).

Table 49: UK payback for loft, cavity & wall insulation

Measure	Annual saving per year	DIY cost	Payback	CO ² saving per year
Loft insulation (if no existing insulation is present - ie, laying 270mm)	Around £175	£50-£350	Less than 2 years (DIY)	Around 730kg
Loft insulation (if topping up - ie, laying 100-270mm)	Around £25	£50-£350	From 2 years (DIY)	Around 210kg
Cavity wall insulation	Up to £135	£100-£350	1-3 years	Around 560kg
Solid wall insulation (internal)	Around £455	£5,500-£8,500	Varies	Around 1,800kg
Solid wall insulation (external)	Around £475	£10,500-£14,500	Varies	Around 1,900kg

Source: Energy Saving Trust. The costs and paybacks shown are approximate, are provided for illustrative purposes only and are based on a gas heated semi-detached house with 3 bedrooms. The savings are the same as those used for CERT, assume a gas price of 4.39p/kWh and include a reduction factor for comfort taking. Installed costs and paybacks assume that installation is undertaken by a professional installer, unless otherwise stated, and both loft and cavity wall insulation costs include a subsidy which can be obtained under CERT. The total, unsubsidised cost of installing either loft or cavity wall insulation is typically around £500.

2) Windows, glazing

The use of advanced window and door glazing solutions can significantly reduce the need for heating and cooling in buildings, thus reducing energy use and CO₂ emissions.

Chart 110: US window demand by shipments (millions of units)



Source: Ducker Worldwide, BofA Merrill Lynch Global Research

Reduced energy consumption, costs & emissions

Anywhere from 20% to 35% of the heat within most homes escapes through inefficient windows and glass, adding up to 10% to national carbon emissions annually (source: US DoE). High-performance windows significantly reduce energy consumption, costs and emissions. Efficiency is primarily measured by a window's U Value or thermal transfer value (ie, how well it prevents heat from escaping), with performance improving significantly in recent years via double and triple glazing and low-e coatings, which can reduce heat loss by up to 70%.

Table 50: Energy efficiency benefits of windows

Glazing type	Overview
Double glazing	Increased insulating capacity (vs single glazing)
Triple glazing	'U value' is up to 8x more efficient than single glazing & 4x basic double glazing
Low-emissivity (low-e) coatings	Adding metallic-oxide based coatings or gas fills between glazing layers to suppress radiative heat flow while letting light pass makes them 2.5-5x more efficient than basic double glazing Coated triple glazing is an essential component of passive / nearly-zero energy buildings
Solar control	Reflect/absorb reduces solar heat gain by up to 75%, combined with low-e to maximise efficiency
Electrochromic / gasochromic	Can reduce the average annual daylight glare index (DGI) and can reduce the peak electric loads by 20-30 percent. The multi-layer tungsten-oxide coating switches provide efficient solar heat gain rejection when required.

Source: Company sources, BofA Merrill Lynch Global Research

Table 51: Typical glazing characteristics

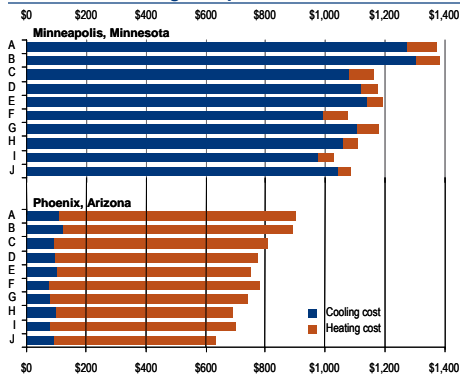
Type of glazing	U-Value (R-Value)	Visible Light Transmittance	UV Light Transmittance*	Solar-Heat-Gain Coefficient	Recommended Applications
Single glazing, clear	1.0 (1.0)	90%	71% (85%)	0.86	None
Double glazing, clear	.50 (2.0)	81%	56% (59%)	0.76	None
Double glazing, low-E, high-solar gain	.35 (2.9)	75%	47% (51%)	0.71	Cold climates; passive solar
Double glazing, high-solar gain, low-E, argon**	.29 (3.4)	75%	47% (51%)	0.71	Cold climates passive solar
Double glazing, moderate-solar gain, low-E, argon	.27 (3.7)	78%	23% (40%)	0.58	Cold or mixed climates
Double glazing, spectrally selective low-E, argon***	.25 (4.0)	71%	16% (33%)	0.39	Hot or mixed climates; west-facing glass
Double glazing (1 inch) with clear Heat film	.21 to .26 (3.8 to 4.8)	20 to 81% (varies with coating type)	<1% (28% to 53%)	.14-.57	Match coating to climate and design needs

Source: Best Practices Guide to Residential, Construction

* Number in () is "damage-weighted transmittance (T-dw)" which includes the portion of visible light that contributes to fading. Lower numbers indicate less fading

** High-solar-gain glass uses "hard-coat" or pyrolytic coatings

Chart 111: Glazing comparison for US houses



Source: Center for Sustainable Building Research. * Annual energy performance for a 2000-square-foot house with different glazing types using a wood or vinyl frame in two U.S. climates. A=Single, clear, B=Single, tint, C=Double, clear, D=Double, tint, E=Double, high-performance tint, F=Double, high solar gain low-E, G=Double, moderate solar gain low-E, H=Double, low solar gain low-E, I=Triple, moderate solar gain low-E, J=Triple, low solar gain low-E

Lower U-values mean lower costs & rapid paybacks

In spite of these technical improvements, the cost of glazing and windows has remained constant or even dropped in real terms. Using advanced glazing solutions can significantly reduce the need for heating and cooling in buildings, thereby reducing energy consumption and associated CO2 emissions. Studies show that savings of more than 100Mt of CO2 could be achieved annually if all Europe's buildings were fitted with advanced energy-saving glass (source: Glass for Europe).

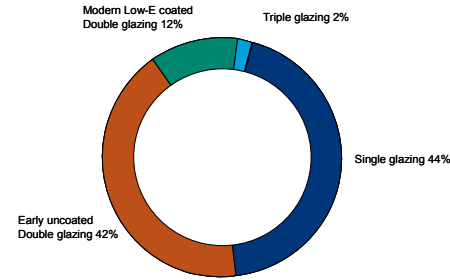
The incremental cost of using high-performance glazing when a building's windows are retrofitted or replaced is small compared with the lifetime saving generated through energy savings. Calculating the ROI of a move to energy-efficient windows is dependent on a number of factors including initial glazing in place, energy needs, energy source, energy price, the efficiency of the building envelope, the existence of incentives, and climate. But, depending on the parameters, the full payback period for energy-efficient windows from replacement is commonly estimated at 3-9Y – whereas windows stay in buildings for an average of 25-30Y, meaning a generation of energy bill and CO2 savings.

Table 52: Payback from windows

Organisation	Efficiency measure	Payback
Glass and Glazing Federation	replacing single glazing with A rated double glazing	Could save £8,211 and 22t of CO2 in a typical detached house, or £5,855 and 16t CO2 in a typical semi-detached house
Pilkington	replacing single glazing with A rated double glazing	Typical semi-detached house could save over £10,000 over a 20 year period
Energy Savings Trust	installing Energy Saving Recommended windows	Average household installing can typically cut CO2 emissions by approximately 0.75t/y
British Fenestration Rating Council (BFRC)	installing energy efficient windows	Can save and reduce energy bill by up to £461/y

Source: BofA Merrill Lynch Global Research estimates

Chart 112: Glazing type distribution in EU

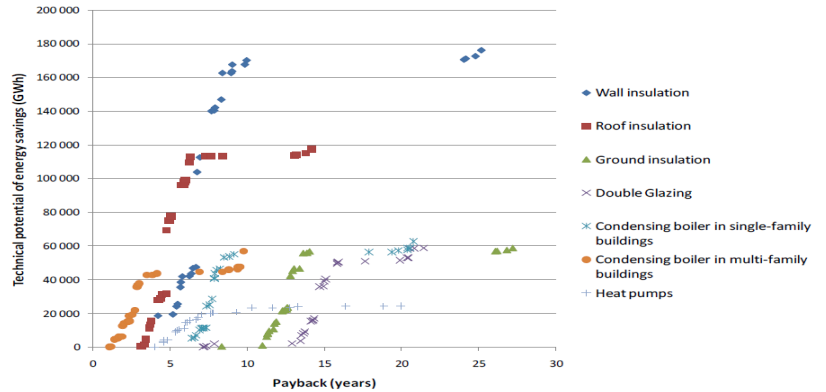


Source: Glass for Europe

Huge growth potential

Studies show that 100mt in CO2 savings could be achieved annually if all of the EU's buildings were fitted with energy-efficient glass – the equivalent of one-third of its building-related energy savings targets. The potential for growth is huge, even in Europe: early uncoated double glazing is still used in 42% of buildings; 44% of windows in the EU's buildings are still single glazed; and <15% of the EU's windows contain energy-saving glass (source: Glass for Europe).

Chart 113: EU-27 cumulative additional energy savings from various EE measures according to their payback time in the residential sector



Source: BofA Merrill Lynch Global Research estimates

3) HVAC

With heating and cooling responsible for 40-60% of energy use and costs in buildings, it is natural that significant efficiency focus is being placed on heating, ventilation, and air conditioning (HVAC). In the US residential sector, HVAC accounts for 39% of total energy use, while in the commercial sector, it accounts for nearly a third (source: DOE). From an efficiency perspective, most buildings waste 10%+ of their energy consumption owing to inefficient HVAC operation. New HVAC systems are up to 30% more efficient than existing systems, making a clear case for attractive growth from upgrades.

Table 53: HVAC products

Segment	Overview	
Commercial	Advanced Thermal Technologies	
	Airside and Terminal Devices	
	Building Services	
	Chillers	
	Controls	
	HVAC incl. parts & supplies	
	Microturbines	
	Unitary Systems (heating/cooling/fan)	
	Residential	Air cleaners
		AC
Air exchangers		
Air handlers (distribute air evenly)		
Furnaces		
Heat pumps		
Humidifiers		
Packaged heating & cooling systems		
Thermostats & controls		
Parts & service		

Source: BofA Merrill Lynch Global Research

Reduced energy consumption, costs & emissions

HVAC is the largest energy consumer in buildings and an area where large savings can be realised. For instance, improper design and installation of HVAC equipment can reduce their efficiency by as much as 30% (source: McKinsey).

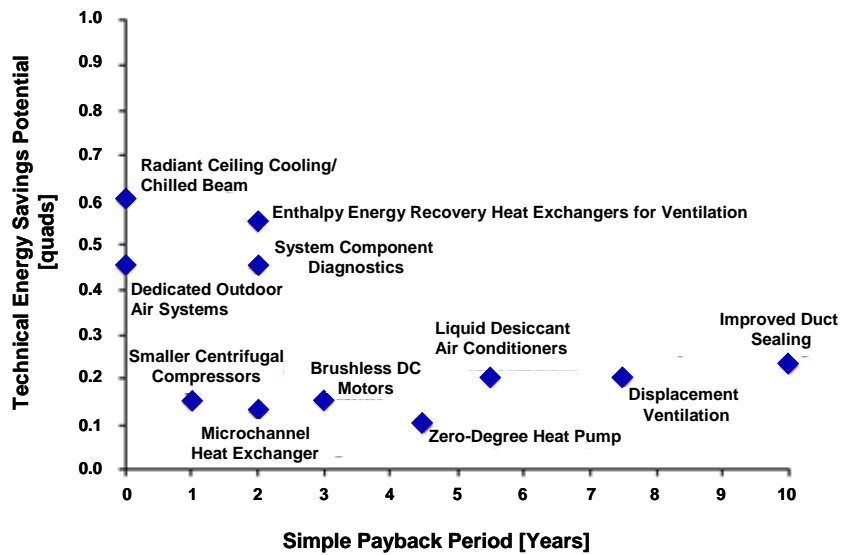
Table 54: Summary of savings potential from four HVAC installation measures

Measure	Energy Savings Potential	Peak Demand Savings Potential
Proper Sizing	2% to 10%	Moderate
Ensure Proper Air Flow	7%	Very Small
Proper Charging	13%	Small
Duct Sealing	10%	Large

Source: Proctor National Study

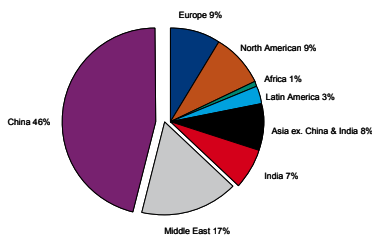
The energy-saving benefit of efficient HVAC systems is on average +30% versus existing systems. The savings can be even higher. For example, efficient measures such as low-lift cooling (ie, chillers, fans pumps) versus a building with a conventional HVAC system can range from 60-74% for temperate to hot climates, to 30-70% in milder climates (source: US DOE).

Chart 114: Estimated technical energy savings potential and simple payback periods for HVAC options



Source: U.S. National Technical Information Service

Chart 115: HVAC/Controls growth value from incremental building stock 2011-2021



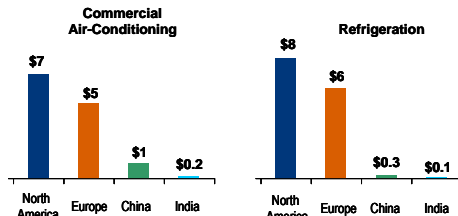
Source: Johnson Controls, BofA Merrill Lynch Global Research

US\$113bn market with strong growth prospects

The global HVAC systems and service market is estimated at around US\$180bn, of which the addressable market opportunity is still a significant US\$113bn (source: Johnson Controls). This includes targeted HVAC services (US\$48bn), non-residential HVAC systems (US\$31bn), global residential (US\$25bn) and NAm residential (US\$9bn). Energy and sustainability – energy solutions building retrofits, distributed renewables, GHG advisory services and retro-commissioning – expand the core addressable market by 20% to US\$137bn (Johnson Controls). The key market drivers are:

- **Replacement demand** – both for commercial and residential buildings, which is approaching double-digit growth, on the back of a desire to reduce energy costs and more stringent regulations. The retrofit of old HVAC systems was a US\$4bn market in the US in 2010, and it is expected to

Chart 116: Growth opportunities (metrics per capita)



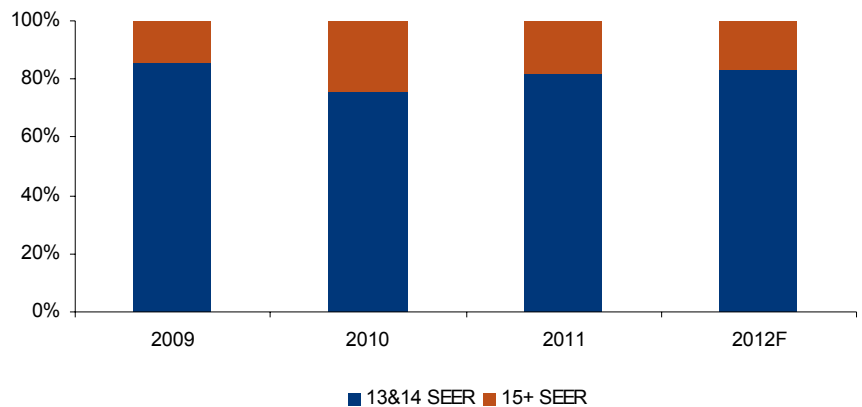
Source: UTC

Executives from leading US HVAC stakeholders, including the AHRI, ACEEE, Alliance, NRDC, NEEP, ASAP, CEC and NWPCC, have signed an agreement to establish regional energy efficiency standards for HVAC appliances with stricter standards for new constructions. The standards are expected to save US\$13bn from 2013-30 and an overall 3.7 quad Btu of energy (ie, energy consumed by 18mn US households/y), and reduce CO2 emissions by 23Mt tons by 2030

double by 2013 (source: Ingersoll Rand). It is also worth noting that HVAC systems last only 10-15 years and 70-80% of HVAC industry sales in the US are derived from the replacement of existing units, ie, there is some catch-up demand from the past few years still to come.

- **Emerging markets** – 90%+ of urban growth in the coming years will be in these markets, which, together with rising living standards, could see AC demand triple before 2030 (source: McKinsey/Vattenfall).
- **Increasingly stringent efficiency standards** – regulators and industry are moving towards stricter efficiency standards for HVAC appliances, as well as energy-efficiency mandates for government buildings. We expect the stringent standards to further drive growth.

Chart 117: Industry shipments by SEER



Source: Ingersoll Rand

HVAC alternatives gaining traction

Alternatives to conventional HVAC systems in commercial buildings are gaining increasing traction as they can reduce HVAC system energy use by up to 75%, as well as help to reduce heating and cooling loads.

Table 55: HVAC alternatives

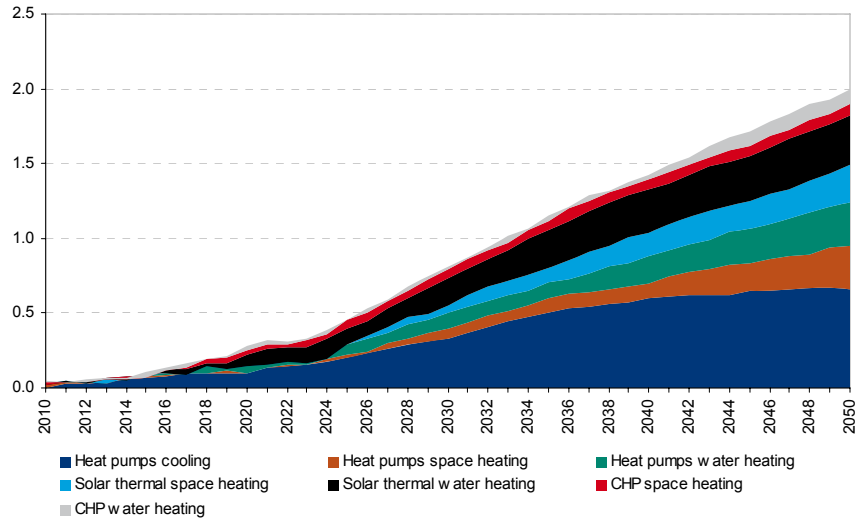
Alternative	Overview
Radiant chilled-ceiling cooling	Circulating water through pipes or lightweight panels results in significant energy savings as water better transports heat than air, the water is supplied at 16-20°C allowing a higher chiller COP when the chiller operates and allowing more frequent use of 'water-side free cooling,' in which the chiller is bypassed altogether and water from the cooling tower is used directly for space cooling.
Displacement ventilation	Air is introduced at low speed through diffusers in the floor or along the sides of a room and is warmed by internal heat sources (occupants, lights, plug-in equipment) as it rises to the top of the room, displacing the air already present. The advantage is that the supply air temperature is significantly higher for the same comfort conditions (c.18°C vs 13°C in a conventional mixing ventilation system). It also permits significantly smaller airflow.

Source: BofA Merrill Lynch Global Research

Huge potential for low/zero carbon heating & cooling technologies

Low/zero-carbon and energy-efficient heating and cooling technologies for buildings have the potential to reduce CO2 emissions by up to 2Gt and save 710Mtoe of energy by 2050 (source: IEA).

Chart 118: Low/zero carbon heating & cooling technologies could save 2Gt CO2 by 2050



Source: IEA, BofA Merrill Lynch Global Research. Excludes the impact of improved building shells on reducing heating and cooling loads.

Most of these technologies – which include solar thermal, combined heat and power (CHP), heat pumps & thermal energy storage – are commercially available today.

Table 56: Low/zero carbon heating & cooling technologies

Technology	Overview
Active solar thermal (AST)	Can provide space and water heating, and cooling needs
Combined heat and power (CHP):	Traditional systems are a mature, transitional technology; micro-CHP, biomass CHP and fuel cell systems (hydrogen) may emerge
Heat pumps	Pumps for cooling and space and water heating are mature, highly efficient technologies that take advantage of renewables
Thermal storage	Can maximise energy savings & efficiency potential of other technologies, facilitate the use of renewables and waste heat Includes sensible (hot water, underground storage) and latent ("phase change" ice storage, micro-encapsulated phase-change materials) and thermo-chemical storage

Source: IEA, BofA Merrill Lynch Global Research

Table 57: Top 25 energy conservation measures (ECM) technologies and applications

Major ECM Category	ECM Type	Technology/ECM Name	Rating*
Controls	General/Special	Upgrade to Direct Digital Control	100%
Industrial	Compressed Air	Implement Compressed Air Utility Management	100%
Water	Reduce Use	Install Low Flow/Use Fixtures	96%
Controls	General/Special	Retro/Recommission Controls for Optimizing Savings	94%
Controls	General/Special	Install Lab Hoods Control - Flow Safe Lab Hoods	94%
Supply Side Management	Manage Energy		
Supply		Change Regulated Utility Rate/Tariff	94%
Water	Smart Metering	Install Smart Meters & software -- for Billing & Accuracy	94%
Electrical	Lighting	Install Lighting Controls	92%
Electrical	Lighting	Replace T-8s for HiBays with T5s	92%
Plant	Boilers	Install Tankless/Instantaneous Water Heaters	92%
Supply Side Management	Manage Energy		
Supply		Change to Interruptible Rates and Use Electric Generators	92%
Architectural	Envelope	Install Weather-Stripping	92%
Electrical	Lighting	Upgrade Fluorescent Fixtures w/ T8 or T5 Lamps and Electronic Ballasts	92%
Electrical	Lighting	Retrofit Incandescent Lamps w/ Compact Fluorescent Lamps	92%

Table 57: Top 25 energy conservation measures (ECM) technologies and applications

Major ECM			
Category	ECM Type	Technology/ECM Name	Rating*
Electrical	Lighting	Replace Exit Sign w/new LED Fixture	92%
Plant	Boilers	Adjust Burner as Regular Maintenance	92%
HVAC (Building/ Non-Plant)	Unit Upgrade	Convert CV to VAV	88%
HVAC (Building/ Non-Plant)	Unit Upgrade	Convert Dual Duct to VAV	88%
Electrical	Lighting	Replace HID HiBay fixtures with T5s or T8s	86%
Electrical	Lighting	Add LED night lights in halls	86%
Architectural	Roof	New Construction with Green Roofs (Plants)	85%
	Water Source Heat		
Plant	Pump Systems	Install Water Source Heat Pump System	83%
Plant	Motors/Pumping	Install VFD/VSDs for Pumps	81%
Controls	Resetting	Reduce Outdoor Air To Design Level	78%
Controls	Resetting	CO2-Based Demand-Controlled Ventilation	78%

Source: Ingersoll Rand. * Score of 0-100% with 100% being the best ranking – based on: Savings potential, Practicality, Commercial viability, Risk management, Business differentiation

iv) Building Automation

See *Industrials & integrated*.

v) Lighting

See *Lighting & LEDs*.

Table 58: BofAML Industrials and Integrated Plays & Energy Efficiency Stock List

Company	EE exposure
DELTA ELECTRONICS	High
GEA	High
HEXCEL CORP	High
LEGRAND	High
SMC CORP	High
SPECTRIS PLC	High
SPIRAX-SARCO	High
ALFA LAVAL	Medium
ALSTOM	Medium
CORNING INC	Medium
DAIKIN INDUSTRIES	Medium
ELECTROLUX AB-SER B	Medium
HONEYWELL	Medium
NEXANS	Medium
PHILIPS ELECTRONICS	Medium
ROCKWELL	Medium
SCHNEIDER	Medium
SIEMENS AG	Medium
ATLAS COPCO	Low
CROMPTON GREAVES	Low
EATON CORP	Low
HEXAGON AB	Low
INVENSYS PLC	Low
METSO OYJ	Low
PRYSMIAN	Low
REXEL SA	Low
SIEMENS LTD	Low
SKF AB	Low
VALLOUREC	Low

Source: BofA Merrill Lynch Global Research. * EE exposure = BofAML estimates of current sales derived from energy efficiency products, services, technologies and solutions

Industrials & integrated plays

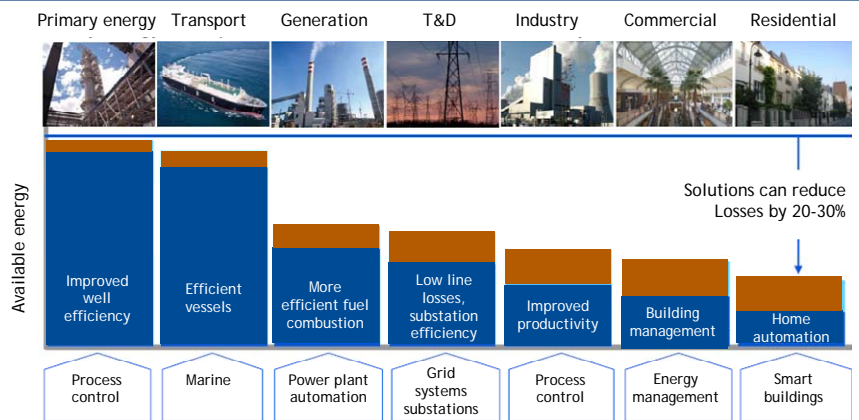
Industry accounts for 28% of global energy consumption and 32% of CO2 emissions (source: IEA). The long-term case for energy efficiency is clear – with 80% of energy lost across the value chain from inefficiencies between the gathering of energy sources and their eventual consumption in industry (source: ABB). The IEA estimates that industry could improve its energy efficiency by almost a third and reduce CO2 emissions by up to 32% via the adoption of currently available best practices and technologies. Moreover, the cost savings are significant – with paybacks for industry, an estimated three years in OECD countries and five years in non-OECD countries (source: IEA).

Industrial and integrated plays – and the Cap Goods sector in particular – are key enablers for improving the energy efficiency of equipment and power, and thus industrial productivity. We expect efficiency to be a long-term growth driver for the sector on the back of megatrends such as: rising energy prices, EM growth in power and automation, expanding production volumes, grid and generation build out, renewable interconnections, and CO2 and environmental regulations.

While energy efficiency will drive product replacement cycles, we assume that the Capital Goods sector currently faces lower growth prospect than between 2004 and 2011. Among the strongest growth outliers are structural opportunities (shale gas, resource scarcity, food/beverage and pharma capex, LNG, transmission, aerospace), the aftermarket and recovery plays (US housing, commercial construction, lighting/LEDs appliances and power). The weakest are those impacted by austerity (government-related spending) and a tougher competitive environment (power, construction equipment, appliance, railway equipment), and GDP plays (European trucks and industrial production).

We believe that a number of stocks are well placed to benefit from the theme of energy efficiency for industrials and integrated plays through their involvement in areas such as automation (building and industrial), controls, grid and smart grid, heat transfer, lighting, power distribution and generation, process management, renewable interconnections, and T&D, among others.

Chart 119: 80% of energy is lost along the value chain from production to consumption



Source: ABB, BofA Merrill Lynch Global Research

See further our EMEA Cap Goods team's *Stand and Deliver* report [Capital Goods, 09 January 2013](#)

Long-term growth vs embracing austerity

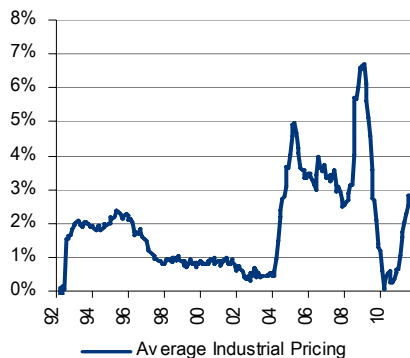
The long-term business case for energy efficiency in the broad industrial space is clear – with 80% of energy lost from production to consumption, and efficiency gains needed across the value chain (source ABB).

Energy efficiency will be a strong factor driving product replacement cycles. But in the near term we assume that the Cap Goods sector will see lower growth than between 2004 and 2011 given the limited short term recovery prospect. Overall, we expect a low growth rate for the sector in 2013, with momentum gradually building into 2014. Despite this volatile outlook, we identify a number of names that look well placed to benefit from energy efficiency trends, even in a more difficult macroeconomic environment.

Tough comparisons vs a golden age

Even including the very deep 2009 recession, we estimate that the Cap Goods sector averaged 5.5% organic growth between 2004 and 2012 (ie, almost 3x the 1997-2003 rate of 2.0%). Looking forward, we expect lower growth to translate into a 4.8% organic rate from 2005-15. We look at the factors that drove this past share price outperformance and ask whether they remain intact:

Chart 120: An exceptional period of pricing for the sector occurred during the BRIC period



Source: BofA Merrill Lynch Global Research

- **Growth is unlikely to match that of 2004-12**, when organic growth was propelled by the development of the BRIC and other emerging economies, a greater focus on energy efficiency, and high levels of borrowing and spending in developed countries. We now expect a gradual recovery in industrial momentum in 2013, steadily building into 2014.
- **Many headwinds to growth.** We expect global growth to be more subdued going forward. Our economists forecast global GDP growth of 3.2% and 3.9% in 2013 and 2014, below the trend rate (excluding 2009 and 2012) enjoyed between 2004 and 2012. Developed market growth is likely to remain hampered by debt and the diminishing scope for further monetary stimulus. Emerging market growth looks set to remain strong (5.3% and 5.7% in 2013E and 2014E), but to slow as economies mature and central banks work harder to balance growth and inflation. Overall, we think growth rates are likely to remain relatively sluggish for most markets and model 2.2% organic growth in 2013E, accelerating to 3.8% in 2014E.
- **The scope for margin improvement is very limited** as the starting point – 12.7% in 2012 – is already high (record was 13.3% in 2011) and will be difficult to improve on. We expect that cost cutting and managing SG&A will be an ongoing focus for companies as they try to protect margins in a low-growth world.

- **Structural opportunities: shale gas, resource scarcity, food/beverage and pharma capex, LNG, transmission, aerospace** – areas where the best growth prospects are over the medium term, and where demand could exceed GDP (and grow without the tailwind of a strong cycle).
- **Aftermarket: amplifying existing trends, protecting downside.** In a flat growth environment, increasing penetration of the installed base (which is growing anyway in most markets) could amplify a company's growth rate. This should also be positive for margins and returns, in our view, given that this business is usually more profitable and highly cash-generative.
- **Recovery plays: US housing, commercial construction, appliances, trucks, autos, marine, power.** These markets are also less vulnerable, in our view, to a global double-dip recession (having less far to fall). Some may have yet to bottom, but they are our preferred recovery end-markets (ie, those with the greatest scope for mean reversion to more normal levels).

Need a discount for structural headwinds or GDP plays

The names with the weakest growth prospects, in our view, are those where either: (1) we have identified specific growth headwinds, or (2) the organic growth rate is largely dependent on GDP or IP growth (which, in our view, is likely to slow over the near term).

- **Austerity - government-related, healthcare, defence, institutional construction, rail and road construction.** These are the end markets that are exposed to developing economy government spending.
- **Tougher competitive environment - power, construction equipment, appliances, railway equipment.** There could be new competitive threats from developed economies (eg, the expansion of CAT/NAV into LatAm truck markets) or, more likely, from the emergence of EM players.
- **GDP plays/markets that have seen the best of the recovery - European trucks, industrial production.** For many segments, the markets have recovered to previous peaks and they now face a slowdown to more normalised levels.

Segments like bearings, trucks (Europe), cutting tools, developed economy automation, air compressors, standard heat exchangers and standard industrial products have already achieved peak growth rates, in our view, with lower (or at least very "average") prospects, and have also benefited from an inventory rebuild. We would highlight the following markets as being back to trend levels of activity (ie, already recovered).

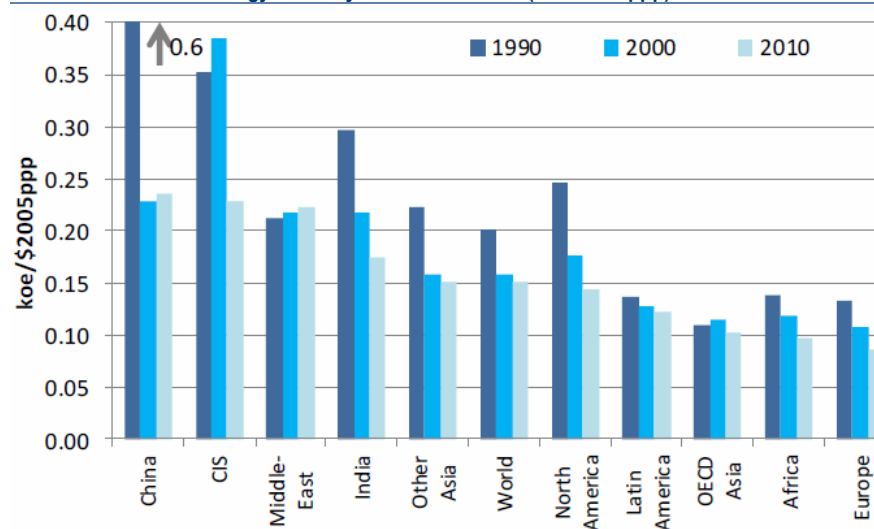
Industry: 30% of global energy use & emissions

Industry accounts for around 28% of global energy consumption and 32% of CO2 emissions (source: IEA). The chemical, petrochemical, iron and steel, pulp and paper, metals and minerals and cement industries account for roughly half of this amount. While energy intensity has been declining in developed markets with the adoption of more efficient technologies, the emerging market industrial boom has meant that overall industrial energy consumption has grown over the past three decades:

Based on adoption of available best practices and technologies, the global manufacturing industry could improve its energy efficiency by almost a third and reduce CO2 emissions by 19-32% (source: IEA)

- The share of electricity in the global industrial fuel mix increased from 26% in 2010 to 32% in 2012 (vs 20% in 1990) at the expense of oil and coal. The share is above 30% in Europe and North America, and above 25% in OECD Asia.
- Industrial electricity use is on the rise in all regions. Non-OECD countries account for 93% of the increase in industrial energy demand, with the fastest rates of growth occurring in India and Indonesia. Industrial energy demand in China is set to overtake that of the entire OECD before 2015.
- Industrial energy intensity has decreased in all regions since 1990 (ie, energy required per unit of value added). Globally it fell 1.6% y/y between 1990-2009 and 1% y/y between 2000 and 2009. It is lowest in Europe and OECD Asia, which are 40% below the world average (vs North America, which is 13% below the world average). The biggest decreases were in EMs, with China and India recording 5.5% y/y and 3.2% y/y reductions between 1990 and 2008, respectively (although they remain 40% and 20% higher than the world average). Over the past 10 years the decline has been lower as energy intensity declined by only 0.5% per year. The IEA forecasts that energy intensity (per unit of GDP produced) will decline by 2.4% per year and CO2 emission intensity by 1.8% per year by 2035 (source: IEA).

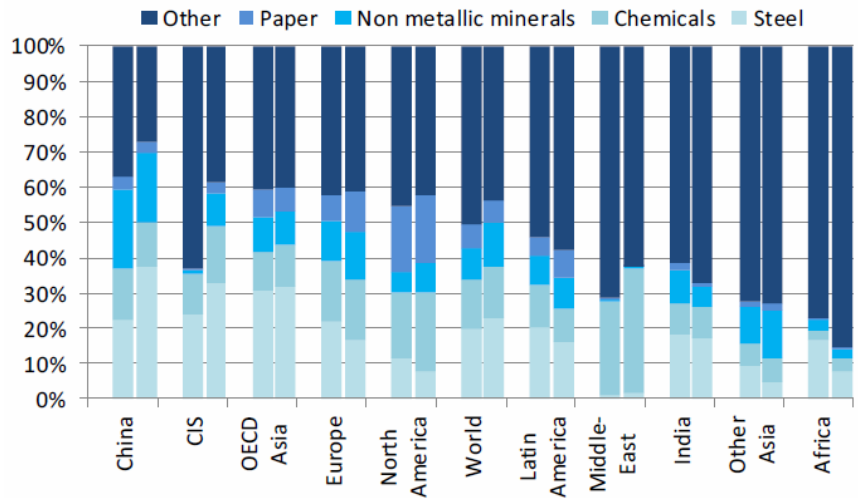
Chart 122: Industrial energy intensity trends 1990-2010 (koe/\$2005ppp)



Source: ABB, BofA Merrill Lynch Global Research

- Recession has hit industrial energy intensity especially in developed markets, where energy-intensive industries have been hit harder than the drop in industrial production.
- Share of energy-intensive industries in industrial consumption is highest in the OECD, the CIS and China (ie, steel, chemicals, and non-metallic minerals) (source: ABB).

Chart 123: Share of energy-intensive industries in industrial consumption (1990 / 2009)



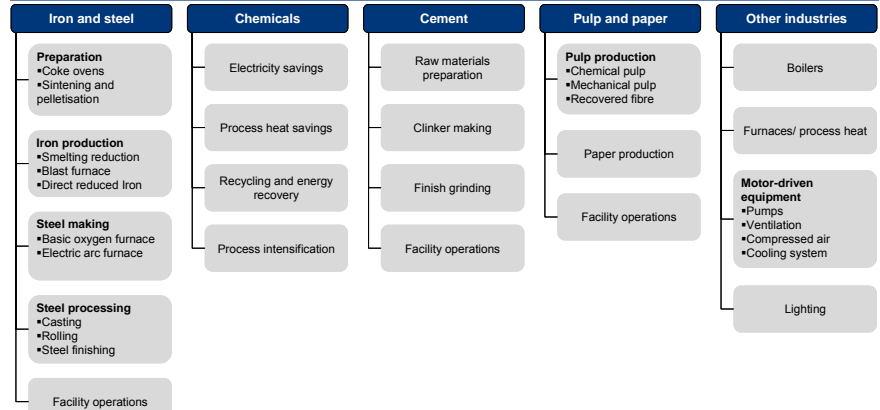
Source: ABB based on Enerdata

49% of EM industry managers have invested in improving energy efficiency vs 34% in DMs and 21% in NAm (source: ABB)

Huge potential on efficiency

The industrial sector accounts for about half of the potential savings in end-use efficiency up to 2020E, with the rest mostly shared between buildings and transport. Energy-efficiency related savings are important in industry because of the numerous opportunities to phase out inefficient and aged infrastructure (source: IEA).

Chart 124: Potential efficiency gains for major industries



Source: WEO outlook 2012

But much more needs to be done

A 2011 white paper and survey by ABB showed that while most industry managers appreciate the importance of energy efficiency in securing long-term financial performance, only 40% say they have invested in capital, plant and equipment within the past three years for this purpose.

Table 59: Energy efficiency overview for largest industrial sectors

Sector	% industrial energy consumption	Energy efficiency overview
Steel	20%	<ul style="list-style-type: none"> Steel industry represents about 20% of global industrial energy consumption and 15% of industrial CO2 emissions from fuel combustion More than half of the world's crude steel production is supplied by China, Japan and the US Greatest efficiency improvements seen by countries using the electric process: uses 50% of energy required by oxygen/blast furnaces. 2008: 38% of steel produced via electric process (vs 28% in 1990)

Table 59: Energy efficiency overview for largest industrial sectors

Sector	% industrial energy consumption	Energy efficiency overview
Chemical industry	>14%	<ul style="list-style-type: none"> Energy consumption could be reduced by 40% globally if main producing countries were to move to efficiency best practices; 60% of those energy savings would be made in China. The US – where chemicals accounted for 25% of industrial consumption in 2009 – had highest energy consumption per unit of value added; energy intensity has increased by 0.8% p.a. since 1990 China has the highest energy intensity among the world's main producers of chemical products because of its coal-based production
Non-metallic metals (cement, glass, ceramics)	13%	<ul style="list-style-type: none"> Cement accounts for 70-80% of branch's consumption & China alone accounts for 50% of energy consumption for cement Average energy consumption per ton of cement produced decreased in the main producing countries from 1990-2008 (ex-France, the US, Turkey and Russia) Most efficient production technologies found in Japan, Mexico and EU (vs Asia & NAM) Efficiency of production depends on process used to produce clinker, the main component in cement manufacturing (dry or wet) & type of kiln. Dry process avoids the need for water evaporation and is less energy-intensive (vs wet); dry kilns w/ pre-heater and pre-calciner are most efficient (vs vertical shaft).
Paper industry	5%	<ul style="list-style-type: none"> Consumption mainly used to produce steam. Largest producers are US (>30% of consumption), Japan, EU, China and Canada Consumption per ton of paper decreased in all main producing countries from 1990-2009 (ex-Brazil and Canada) Efficiency related to technical age of production facilities (ie, ageing US mills lead to higher consumption). Other factors: % of imported pulp, process used to manufacture pulp (mechanical = highest consumer), % recycled paper.
Aluminium	NA	<ul style="list-style-type: none"> Production is made up of primary aluminium production & recycling, former is 20x more energy intensive than recycling. Main producers = 60% of production (China, Russia, NAM, Australia, Brazil) Specific electricity consumption for primary aluminium production decreased by 4% since 1990. Sharpest decrease was in North America and Africa. Primary production requires large amounts of electricity for smelting, while alumina plants use steam energy (CHP production in modern facilities). For smelters: Hall-Héroult system w/ pre-baked anodes (10% of market) has high energy efficiency w/ 13-16.5 MWh/t; vs Søderberg cell with in-situ baked electrodes (70% of market), at 15-18 MWh/t. Long-term, electrolysis process designs using aluminium chloride or carbothermic processes could become the production norm

Source: ABB, IEA, company sources, BofA Merrill Lynch Global Research

See further section on *Buildings*

Building automation

As explored further in our section on *Buildings*, energy consumption within buildings accounts for the single largest component of global energy use and CO2 emissions, at c.40% and c.30% respectively. The biggest culprits in residential and commercial buildings are heating and cooling, which, together with lighting, can account for up to 60% of buildings' energy consumption. Alongside tackling buildings' thermal envelopes, building automation will play an important role in reducing energy use by the targeted 30% to 50% by 2030-50 (source: IEA). The key market players are Siemens and Schneider in Europe and Honeywell and Johnson Controls in the US. Other players include GE, Ingersoll Rand, Tyco and UTC.

US\$80bn+ market by 2016

The global building automation and control systems market was estimated to be worth US\$41bn in 2011 and is expected to grow to US\$82bn in 2016 – a CAGR of 14.8% from 2011-16 (source: Products and Technologies). These figures encompass building automation in a broad sense including access controls, building management systems, communication protocols, entertainment controls, lighting controls, management and metering, outdoor controls, protocols and standards, security controls; wireless technologies. Applications include commercial, industrial, infrastructure and institutional use.

Intelligent building control

Building automation reduces energy use via intelligent building control, whereby sensors (humidity, temperature, motion detectors, etc) are connected with controllers or actuators, allowing building administrators to monitor and control functions such as climate control, HVAC, lighting, operation and sun control more efficiently. It allows energy to be used only when required, only in the amount actually needed and enables better control of "in/desirable" external factors impacting energy balance.

Table 60: Potential energy savings from building automation

Automation measure	Potential savings
Room heating control	14-25%
Heating automation	7-17%
Shutter control	9-32%
Lighting control	25-58%
AC control	20-45%
Average energy saving	11-31%

Source: ABB based on scientific studies

For example, with the KNX OSI-based network communications protocol for intelligent buildings, all sensors (buttons, motion detectors etc.) are interconnected to the actuators (dimming or roller shutter actuators etc.) via a data cable as opposed to directly wired switches and consumers (conventional installation). The actuators control the power circuit to the consumer. Communication for all devices is implemented using data telegrams on the same bus cable. The sensors send commands and the actuators “listen in” and execute a defined function as soon as they are addressed.

Up to 30% energy savings & 2-10Y ROI

Although energy savings will depend on the type of automation system installed or retrofitted, company and scientific studies show that coordinated behaviour across multiple systems can result in overall energy savings of 11-31%. Based on energy savings alone, this would mean an ROI of 2-10 years, which implies that building automation is well positioned vis-à-vis building envelope efficiency measures (10+ year payback) or modernisation of HVAC (5+ year payback). Beside energy savings, having building automation in place increases property values.

Recession hitting the market near-term

The biggest argument for adopting building automation, especially in a recessionary environment, is that it cuts down on energy use and energy costs, which are a huge proportion of long-term TCO and the subject of growing CIO/CFO interest. That said, building automation is likely to remain under pressure from slower forecast growth in non-residential due to weaker than expected spending across most sectors, the slow recovery in office and commercial, and weakness in the residential HVAC business.

But some positive signs

Positively, institutional and industrial markets are leading the improvement, there is strong growth in Asia-Pacific (eg, Australia, China, Singapore) and there is potential upside from our Cap Goods team’s preferred recovery plays – US housing and commercial construction (ie, those with the greatest scope for mean reversion to more normal levels)

Long-term drivers are favourable

Long-term growth drivers are extremely favourable, particularly for emerging markets:

- **The urban population is expected to grow by 1.5bn** people globally over the next 20 years (source: UN). This places greater pressure on industrial plants and residential and commercial buildings, such as hospitals, schools, offices, and shopping centres, to be as efficient as possible.
- **Commercial building stock growth:** While there is ~400bn ft² of commercial building space globally, over the next 10 years more than an additional 110bn ft² will be built, 80%+ in emerging markets. (source: Johnson Controls)

In China alone by 2020, industrial motors will consume >30% of electricity and provide >10% of carbon emissions - likely 1-2% of global emissions (source: ARM)

Optimising motor-drive systems worldwide could save the power equivalent of the annual output of 250 nuclear reactors (source: ABB)

Industrial automation

Industry consumes about 40% of all electricity generated, according to the IEA – with the cement, chemical and iron & steel industries being the most energy-intensive. It should remain the largest electricity end-use sector through 2035. Close to 70% of the electricity consumed by industry is used by the electrical motors driving machines, compressors, fans, pumps and conveyors in almost all industrial sectors (source: IEA). Siemens estimate the overall addressable Industrial Automation (IA) market is around €146bn at present (ABB estimate a similar figure of \$180bn for industrial automation, and another \$120bn for the process automation market including distributed control systems, instrumentation and service). Siemens thinks the IA market should grow at about 4% p.a. and this looks realistic to us (maybe even conservative as ABB estimate >6% p.a.). We think IA is likely to grow faster and/or more consistently than many other end markets we analyse, which are struggling to grow at all.

Replacing technologies such as inefficient compressors, which often lose up to 80% of input energy as heat, could contribute to radical energy cuts. Energy efficiency via measures such as high-efficiency motors and variable speed drives offers huge energy and cost saving potential. The key market players are Siemens, ABB, Emerson, Schneider, Rockwell, Invensys and Atlas Copco.

Huge untapped energy saving & cost potential

An estimated 65% of electrical energy is used by electric motors of all types around the world (source: ABB). Even though these motors efficiently convert electrical energy into mechanical energy, some 20% of this is lost by wasteful throttling mechanisms in many industrial processes.

Most motors run at a fixed speed – ie, throttling valves in pump systems, vanes in fans, belt drives, gearboxes, hydraulic couplings – regardless of the actual output needed. This constant stream of power and torque means billions of dollars in wasted energy.

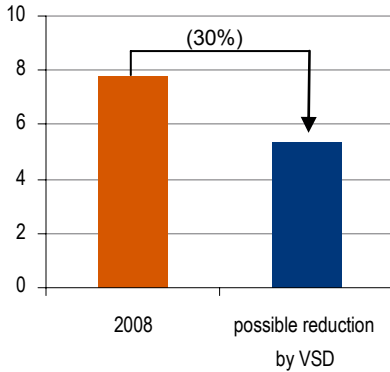
Switching to energy-efficient motor-driven systems could save Europe alone up to 227 TWh in electricity consumption per year, equivalent to a reduction of €10bn per year in operating costs for industry (source: ABB). Globally, efficient motors could save the US 2% of total electricity consumption, the EU 7%, and China 2-10% (source: ARM).

Table 61: Savings potential for motor systems in the EU is over 200bn kWh/year

Motor system	EU-15	EU-27	France	Germany	Italy	UK
High efficiency motors	24	27	4	6	4	3
Variable speed drives	45	50	8	10	7	6
Pumps, fans, compressors	112	125	19	26	17	15
Total electricity saving potential	181	202	31	42	28	24

Source: ABB

Chart 125: Energy consumption of electric motors (tn kWh)



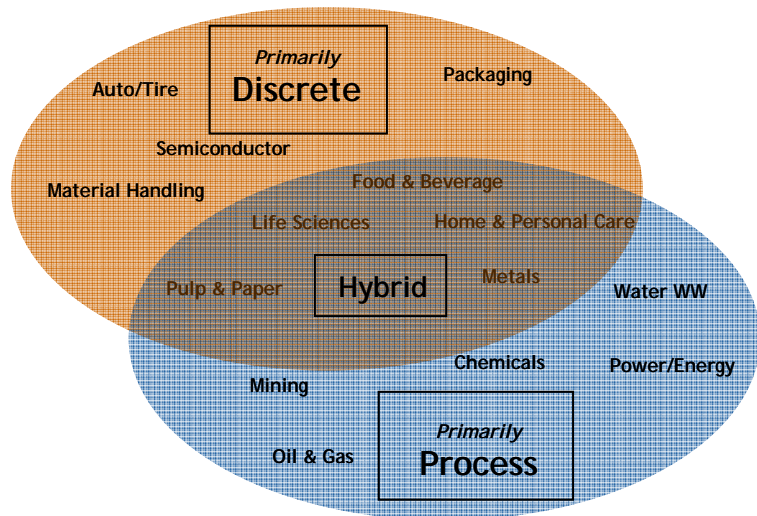
Source: Infineon, IEA

Intelligent motor control via variable speed drives

The most effective way of controlling a motor's speed is through variable speed drives (VSD). VSDs can reduce energy use by up to 30% by matching driver speed or motor output to the actual energy requirements of an application (ie, load-dependent speed control). In pump and fan applications, they can cut the energy bill by as much as 60%, as a pump or fan running at half speed uses only a quarter of the energy of one running at full speed.

However, less than 10% of motors are equipped with such devices (source: ABB), meaning tremendous opportunity, over time, to retrofit millions of installed motors. While industrial demand should continue for years, industrial customers are also seeking an intelligent motor control package which can capture data from these devices through IT systems that interface with factory information systems.

Chart 126: Industrial automation overview

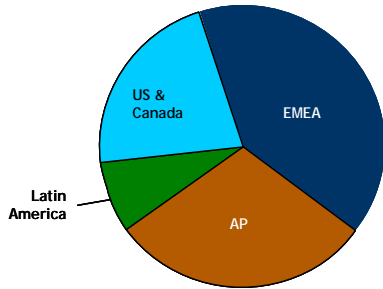


Source: Rockwell, BofA Merrill Lynch Global Research

Cost & regulation will be key drivers

Each US\$1 spent on purchasing a more efficient electrical motor can save US\$100 in energy costs over the motor's lifetime (source: Infineon). In addition to the cost advantages, VSDs benefit from increasing regulation of electric motors, with the EU stipulating since mid-2011 that electric motors in the 750-375kWh range must have electronic speed control; more stringent regulations are set to follow in 2015 and 2017. Canada and the US have passed similar regulations.

Chart 127: Automation market



Source: Rockwell, BofA Merrill Lynch Global Research

See further section on *Lighting and LEDs*

US\$120-150bn+ market growing faster than global GDP

The industrial automation market is estimated at US\$120-159bn in 2012 and is expected to grow to more than US\$185-200bn by 2015/16E (source: IMS Research, MarketsandMarkets). Key market drivers include energy efficiency, commodity demand, use of energy (oil & gas), factory automation, and transportation and mobility.

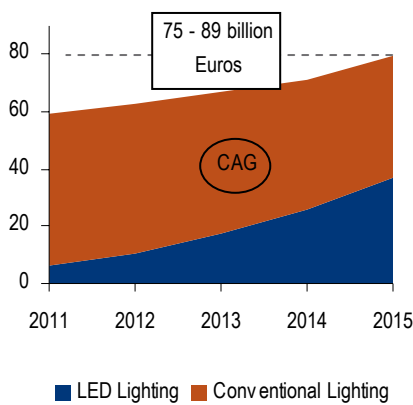
Near-term environment looking increasingly attractive

2009 to 2011 saw the Automation market suffer from its exposure to general industrial capex trends. However, 2012 has seen companies experiencing broad-based order and revenue growth across all regions – and 2013 forecasts look strong. Our Cap Goods team sees automation products as having some of the strongest near-term growth prospects in terms of pricing. Asian automation in particular is seeing strong growth, with China pushing to expand more into export markets. It is expected to invest heavily to improve the quality of its products and automate more processes as labour costs inflate.

Lighting

LEDs and lighting stand to be among the major beneficiaries of energy efficiency, in our view. Lighting consumes 19% of the world's electricity output and is extremely wasteful with up to 30-75% of lighting systems considered inefficient (source: IEA). Without efficiency breakthroughs, it is estimated that electricity consumption by lighting will increase by 60% in the next 20 years (source: UNEP). New technologies can reduce electricity consumption by up to two-thirds. Moreover, energy-efficient lighting sources such as CFLs, LEDs, luminaries, control gear and intelligent lighting control tools and concepts can thus significantly reduce both electricity use and CO2 emissions.

Chart 128: Global lighting market (EUR billions)

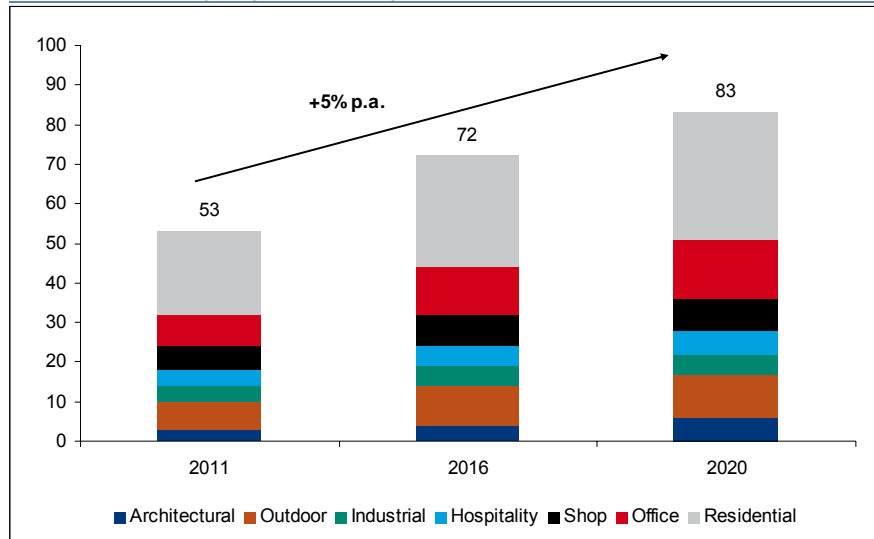


Source: Phillips

We anticipate strong growth for energy-efficient lighting solutions, helping the global lighting market to grow at a 5-7% CAGR to €75-89bn by 2015 (source: Phillips). While a lacklustre macro economy has impacted the general lighting market in the near term, LEDs in lighting are emerging as the biggest growth opportunity in the medium to long term. *Short-term usage will be driven by mobile phones and TVs, with 60-70% of new TVs having LED backlighting. While oversupply remains an issue, we see the industry pulling into a healthier supply/demand balance past 2014.* A speedier drop in LED lighting prices – including the 2013 magic price point breakthrough of Cree's sub-US\$10 LED bulb for Home Depot – could be a major breakthrough for residential solutions. LEDs could represent 45% of the global lighting market by 2015 (source: Phillips) and residential LEDs could make up 70% of the general light market by 2020 (source: McKinsey).

We believe that a number of companies are well placed to benefit from the theme of energy efficiency in LEDs and lighting through their involvement in areas such as chips, CFLs, CCFLs, components, deposition equipment, LEDs, lighting management, lighting solutions, luminaries, MOCVD equipment, and process equipment, among others.

Chart 129: General lighting market size by application (EUR billions)



Source: McKinsey, BofA Merrill Lynch Global research

Power: largest energy-consuming industry

Power generation is by far the largest energy-consuming industry. It is also relatively inefficient, with only about 35% of fuel consumed being converted into electricity. There is huge margin for improvement with a global move to thermal efficiency levels of 45% (ie, the average of the top 10 countries) – this would reduce fossil fuel consumption for power generation by 700Mtoe, or about 30%, and CO2 emissions per kWh produced by about 20% (ie, 2.3 GtCO2).

Power is set to become a US\$130bn market by 2015 based on the current 5-10% CAGR, with efficiency being a key driver vis-à-vis economic growth and increasing electricity consumption, ageing networks and power plants, renewables integration, grid and generation build out, and smart grid and environmental regulations.

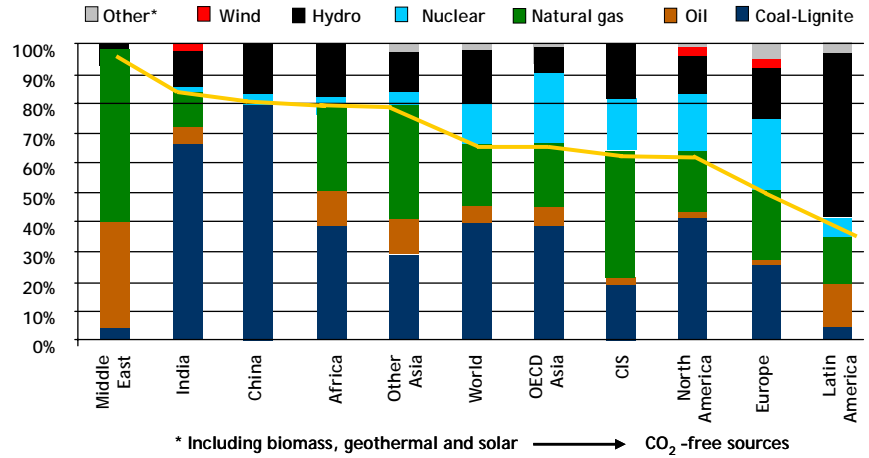
Some progress, but efficiency still a long way off

The last decade has seen improvements in the energy efficiency of the global power sector, but there is still significant work to be done in terms of energy mix, T&D losses and CO2 emissions:

- **Coal is still king, but low-CO2 sources are 1/3 of the energy mix** - Globally, thermal sources represented 60%+ of total electricity production in 2009. Natural gas accounted for 20%. Low / “zero” CO2 sources represent about a third of the power mix.

The spread of gas combined cycle plants over the past decade has helped to improve thermal efficiency levels

Chart 130: Power generation by source (2009)



Source: ABB based on Enerdata

- Global efficiency of thermal plants stood at 35% in 2009. North America and the EU were at 40%, while OECD Asia and Latin America were also very efficient (relatively speaking). Most emerging markets remain below the global average, with China and India hit by their heavy reliance on coal despite efforts to improve efficiency.

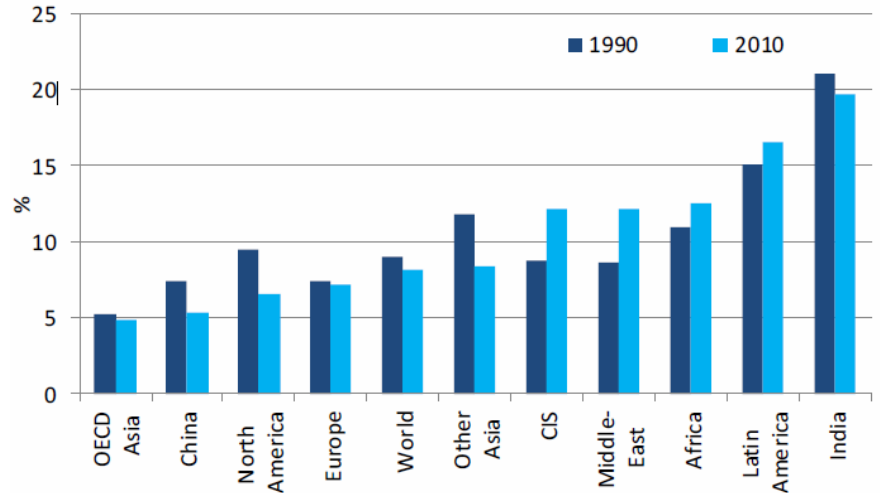
Chart 131: Energy efficiency of total electricity generation (2010)



Source: ABB based on Enerdata

- Global T&D losses were at 8.5% of distributed volumes in 2010. Developed markets have the most efficient grids thanks to the use of low-loss conductors and transformers, the standardisation and upgrading of T&D voltages, and reactive power control. Emerging markets – India and Latin America in particular – have the highest losses, at 15-20%.

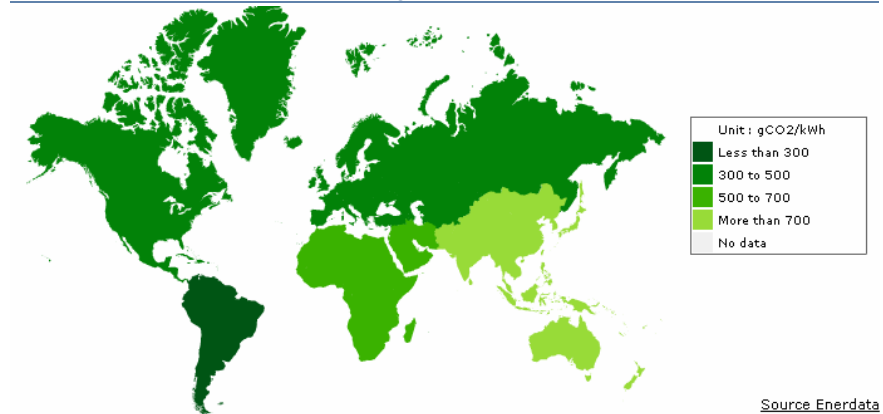
Chart 132: T&D losses 2000-2010



Source: ABB based on Enerdata

- Global CO₂ emission factor was 520gCO₂/kWh in 2010. 20% of countries had a factor of 200gCO₂/kWh but over 10% had a factor of 800gCO₂/kWh. The CO₂ emission factor increased by 0.3%/year worldwide from 1990-2009 on the back of emerging market coal use.

Chart 133: CO₂ emission factor in power generation (2010)



Source: ABB based on Enerdata

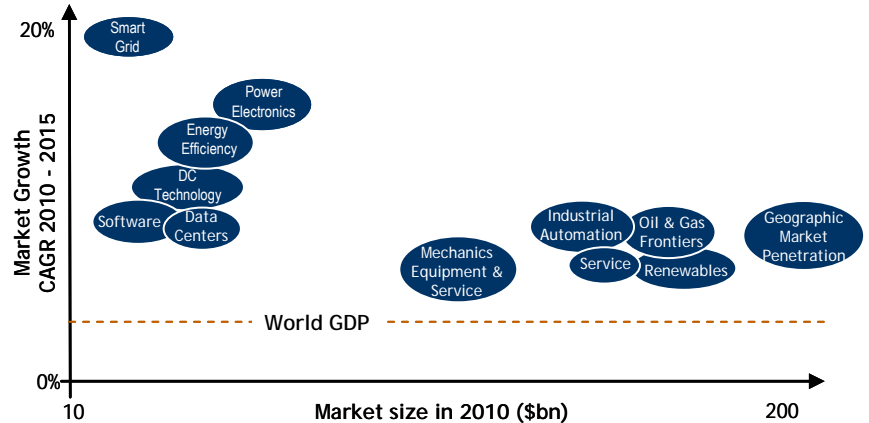
Huge energy & CO₂ savings potential

If the world were to reach thermal efficiency levels of 45% (ie, the average of the top 10 countries), then fossil fuel consumption for power generation could be reduced by 700Mtoe, or about 30%, and CO₂ emissions per kWh produced would be reduced by about 20% (ie, 2.3 GtCO₂).

US\$120bn market by 2015

Assuming average annual global GDP growth of 3-4%, the power market is expected to grow at a 4% CAGR from 2010 to 2015 (source: ABB). Taking into account our slightly more conservative assumptions on US GDP growth (2% to 3% CAGR until 2015) translates into growth of the US market from US\$100bn in 2010 to US\$120bn in 2015E.

Chart 134: Market is growing faster than global GDP



Source: ABB, BofA Merrill Lynch Global Research

5-10% growth to 2015

Emerging markets should see the highest growth at +10%, followed by utility sectors at +8%, industrial sectors at +7% and developed mid-markets at +5% (source: ABB). This will mean opportunities for power capacity and infrastructure, grid upgrades, the smart grid, renewables and interconnections on the back of the drivers outlined below.

Table 62: Key power market drivers 2010-15

Driver	Growth	Europe	Growth	Americas	Growth	Asia & MEA	Market growth
Cost pressure, ageing infrastructure	3	-Drive for energy efficiency in T&D	4	-Increasing power outages in US	1	-Reduced blackouts	•EMs +10%
Distributed generation	4	-Interconnections	2	-Wind in key US states	1	-Likely to come in India	•Utility sectors: 8%
Remote bulk generation from renewables	4	-Grid upgrades	2	-Large hydro in LatAm	5	-Large hydro, offshore wind & utility solar	•Industrial sectors: 7%
Urbanisation	1	-Germany & UK offshore wind connections	1	-SAM	4	-Increasing population	•Mature markets: +5%
		-Eastern Europe				-Growing middle class	

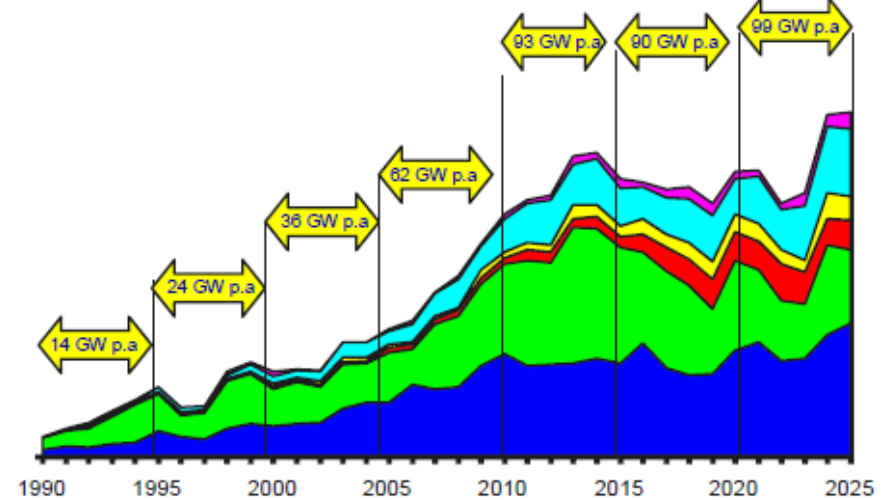
Source: ABB. Growth: 4 = higher, 1 = lower

Economic growth and increasing electricity consumption

Global demand for electricity is set to continue to grow faster than demand for any other final form of energy until 2035. It is expected to double over the next 25 years, with emerging markets expanding 3x faster than OECD countries. EM electricity consumption per capita is projected to grow exponentially, and total electricity consumption is forecast to increase fourfold between 2006 and 2030. The share of electricity in the total global energy mix is expected to grow from 17% in 2005 to 22% in 2030 (source: ABB).

This has important long-term implications for energy efficiency, as 60% of the 2030 installed base has yet to be built. For new coal plants, a +20ppt rise in efficiency saves 40% in CO2 emissions, for gas +20ppt in efficiency saves 33% in CO2 (source: Alstom).

Chart 135: Fleet age 1990-2025

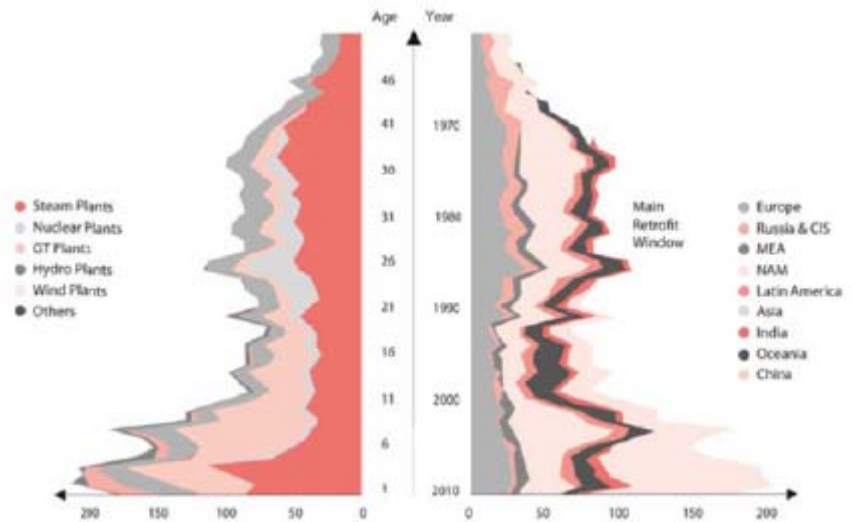


Source: Alstom

Ageing networks and power plants

Ageing infrastructure, especially in North America and the EU, will mean rising modernisation, service and replacement needs, as only 41% of emissions from currently installed industrial infrastructure are locked in through 2035 in OECD countries (WEO 2012). For example, retrofits via plant optimisation and turbine retrofits can reduce CO2 emissions by 5%, boiler retrofits by 3% and automation retrofits by 1% (source: Alstom)

Chart 136: World installed base in 2010



Source: Alstom based on IEA

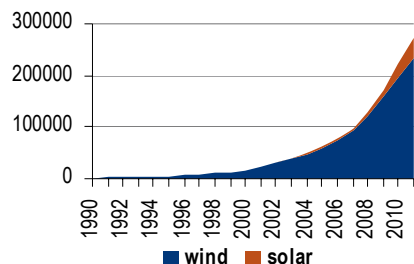
Cross Reference

[Renewable Energy, 10 January 2012](#)

Renewable integration, moving towards grid parity

Renewables pose power challenges in terms of balancing supply and demand in real time given their unpredictable / intermittent nature. Take-up is also largely contingent on cost. While the cost of renewables has fallen over the past three years, so have benchmark power prices, especially in the US, due to shale gas production. Renewables remain uncompetitive and demand will continue to be driven by regulatory targets and subsidies, in our view. The story in Europe is

Chart 137: Cumulative wind & solar build-out



Source: BofA Merrill Lynch Global Research

Chart 138: €40bn grid market by 2014



Source: Alstom

slightly better as gas prices retain a closer link to oil but spreads are minimal, reflecting the high reserve margins, and carbon prices have recently collapsed due to a worsened outlook for industrial production. Renewables are more often competitive in some emerging markets because of the high cost of importing LNG and sometimes better renewable yields (better wind load factors or sunnier conditions). We highlight that the cost of wind power was actually slightly lower than gas in the most recent Brazil auction and in certain regions in Australia as well.

The table below is our European Renewables analyst's attempt to illustrate the relative new build costs of different technologies in Europe (so reflects a narrow oil-gas spread, spot CO2 pricing and average weather based load factors). Over the past 3-4 years, the cost of wind has fallen by about 25-30% per MWh and PV solar has fallen by over 50%. We believe PV has overtaken CSP. Offshore wind remains very expensive but costs should fall substantially once the next generation of turbines comes on the market in 2015 and beyond. Unfortunately, current power prices are well below new entrant costs because of low spreads, so renewables are not quite as close to grid parity as the table suggests.

Table 63: New build cost in Europe

Technology	Cost (€/MWh)
Hydro	53
Nuclear	58
Coal (at \$115/t with €10/t CO2)	66
Geothermal	67
Gas (at \$100 oil linked supply)	71
Onshore Wind	73
CCS	93
Offshore Wind	108
PV	191
CSP (concentrated solar power/solar thermal)	220

Source: BofA Merrill Lynch Global Research

Grid and generation build-out, EM key to €40bn market

Electricity demand is growing faster than primary energy growth, with the world needing 1GW of power generation and related grid infrastructure every week for the next 20 years if it is to meet its anticipated energy needs in 2030. The market is sustained by large governmental investment programmes for both thermal and renewable energy, especially in Asia.

Major grid and generation markets

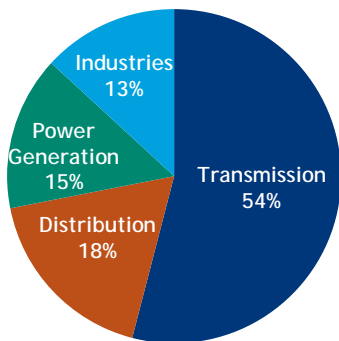
Market	% grid	Drivers
China	19%	-Biggest individual market -Recurring business to sustain growth in consumption -Power generation located far from the mega cities: need to support economic growth which is linked to its power supply -Investment in large HVDC and Ultra High Voltage (UHV) interconnections to move bulk energy to cities
Middle East & Africa	18%	-Consolidating market due to general slowdown of grid investment -Sustained investment in specific markets eg, Saudi Arabia -Future interconnections between renewable resources in North Africa & EU
Europe	17%	-Environmental targets (the 20/20/20 directive) -Network built on individual country grids: need to enable increased power transmission -Large HVDC projects being deployed and planned (DC offshore wind connections (UK, Germany), HVDC Interconnections -Recurring business volume increasing due to infrastructure renewal -Major renewable resources in Northern Africa will be connected to EU
Eastern Asia and Pacific	13%	-Developed countries consolidating and improving their grid (Korea, Australia...) -Developing countries need investment to sustain their industrial growth

Major grid and generation markets

Market	% grid	Drivers
North America	12%	-Ageing AC network -Need to improve power quality and network reliability -Electrical infrastructure upgrade planned -Major interconnection project to access additional capacity (on & offshore wind and hydro) in the planning
Latin America	9%	-Strong investment in generation and transmission capacity planned in Brazil -Large infrastructure projects in Argentina and Chile -Power generation far from consumers: need to interconnect regions / countries for shared energy reserves
India	9%	-Continuous increase in recurring business and additional opportunities due to deployment of new generation capability -Resource and load locations: long distance bulk transmission; alleviate congestion from Bhutan -Push on efficiency vis-à-vis national grid
Russia	3%	-Grid modernization a key objective of the government in the short to mid term

Source: Alstom, company sources, BofA Merrill Lynch Global Research

Chart 139: Grid market by end customer



Source: Alstom, BofA Merrill Lynch Global Research

A significant proportion of the growth will also come from major HVDC (high voltage direct current) projects. HVDC allows for bulk power transmission over greater distances, higher efficiency / lower losses, has a reduced cost per MW, enables integration of renewables, facilitates grid interconnections and optimises generation capacity, and is suitable for overhead, underground and sub-sea transmission. HVDC could become a €50bn market by 2020 with China, the Americas, India and the EU offering the greatest potential (source: ABB)

Chart 140: Solid long term market fundamentals for the grid

Long term drivers	Global importance	Segment				Impact on grid market
		HV products	Smart grid	Power electronics	Service	
Electricity consumption & generation	High	High	Medium	Medium	High	? Main driver for grid expansion, new substations and related HV products ? Challenge to improve energy efficiency across the value chain
Ageing of the installed infrastructure	Medium	Medium	Medium	Medium	High	? Challenge to maintain grid reliability ? Driver for replacement market
Increase of renewables within energy mix	Medium	Medium	High	High	Medium	? Challenge to maintain grid reliability ? Impact on HVDC for interconnections and offshore wind tie-in ? Impact on smart grid for renewable energy management systems

Source: Alstom, BofA Merrill Lynch Global Research

Table 64: Grid and generation market

Products	Mkt. CAGR 2010-15	Key products	Business overview
High voltage (66-1,200kv)	2-5%	Gas insulated switchgear, air insulated & hybrid switchgear, generator circuit breakers	-Global & local standards -Rigid utility certification process -Products configured & assembled to order -Majority of sales to utilities -Transmission is a key driver
Medium voltage (1+66kv)	5-6%	Primary switchgear, secondary switchgear apparatus, distribution automation, modular solutions, service	-Local standards -Products with varying degrees of customization -Fragmented market -Diverse customer & channel mix -Distribution is a key driver

Table 64: Grid and generation market

Products	Mkt. CAGR 2010-15	Key products	Business overview
Power transformers	2-5%	Mainstream, Ultra-high voltage, HVDC, industrial, phase shifters	-Global standards -Global players -Emerging competitors -Some applications require cutting edge technology
Distribution transformers	5-8%	Oil-type, dry-type	-Local standards -Mainly local/regional players -Fragmented market
Speciality transformers & other	5-8%	Application-specific, traction, components, service	-Diverse requirements -Industrial focus -Customers drive innovation -OEM market for components -Fragmented service market

Source: ABB

See further section on *Smart grid & energy storage, the ElectricNet*

Smart grids, main segment of long-term growth

The smart grid represents the main segment of growth in the grid management industry for the next decade. It is growing at 11% CAGR from 2012-13 to 2015-16E (Source: Alstom) and by 2020, our Alternative Energy team estimates it could represent a global market of up \$63bn. Key market drivers include improved grid reliability and stability, increasing distributed generation, renewable energy integration (intermittency), reducing consumption peaks, increasing energy efficiency, EV integration, a greater focus on cyber-security, and reducing CO2 emissions. The smart grid should also facilitate and improve prospects for greater energy efficiency in buildings, IT, power generation and T&D, and transport. The key technology influencers will be AC and DC technology, demand (AMI/AMR) and energy storage.

Table 65: Current vs evolving grid

Current grids	Evolving grids
Centralised	More distributed
Stable, reliable, adjustable generation (fossil fuels, nuclear, hydro)	Renewable generation is unstable, unreliable (wind, solar)
Supply follows the demand	Power is available when people don't need it
Instant delivery	
Limited grid accessibility for new producers	More grid accessibility & multi-direction flow
One-directional power flow	Demand management and e-mobility add to complexity
Minimal storage needs	Storage needed to balance supply and demand

Source: BofA Merrill Lynch Global Research estimates

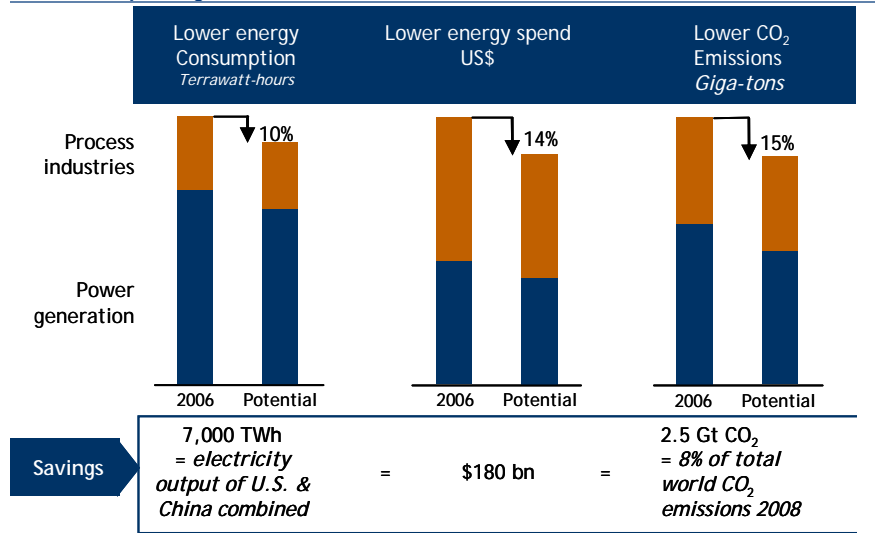
AMI, "Internetization" of utility services

An important element of the smart grid is advanced metering infrastructure (AMI), including the roll-out of smart electric, gas and water meters. Of the combined 2.7bn electric, gas, and water meters worldwide, less than 15% are automated. While North America is expected to remain a leader, achieving 50% smart electric meter penetration this year, opportunities in EMs – particularly in Asia – provide the greatest long-term upside. Based on announced projects alone, we expect more than 200mn meters to be installed in traditional markets by 2018 with the global smart meter market to reach US\$15bn.

Environmental regulations on CO2 & energy efficiency

The long-term trend will continue to be towards lowering energy consumption spend via diversification of the energy mix with the adoption of lower CO2 or CO2-free technologies, efficiency improvements, and ultimately carbon capture and storage (CCS).

Chart 141: Savings potential from applying energy-efficient technologies in process industries & power generation



Source: ABB

Growth potential on the medium term (as of 2015)

Our Capital Goods team thinks power systems and large T&D projects are on the rise in both Asia and US/Europe. Power products have competitive risks but grid structures will become more complicated ('smart grid' – see below section on *Smart Grid and Energy Storage*), which offers structural growth opportunities for ABB, Alstom and Siemens.

Given reserve ratios in Europe and regulatory issues in the US, the power equipment sector in developed markets remains relatively depressed. The large power players like Siemens and Alstom, and a number of suppliers (GEA, Hexagon, Metso, Bodycote, IMI, Rotork, Invensys and Weir) should benefit, in our view.

Tougher competition from EM players

The market has had concerns about the power equipment sector, given the rise of Korean and Chinese power equipment companies. Western players have had to adapt to try and meet the challenge head-on, forming JVs with Asian players, relocating cost bases, and moving into more value-added areas (eg, software). The headwinds are significant in this sector, but widely recognised for the Western players, in our view (Alstom, ABB, Siemens, and GEA).

Table 66: BofAML IT & Energy Efficiency Stock List

ANALOG DEVICES	High
ARM HOLDINGS	High
ASML	High
EMC CORPORATION	High
FLEETMatics GROUP	High
EQUINIX INC	High
IBM	High
INFINEON TECH.	High
INTEL	High
INTERXION	High
LINEAR TECHNOLOGY	High
MAXIM INTEGRATED	High
SALESFORCE.COM	High
SANKEN ELECTRIC CO	High
SPLUNK	High
STMICROELECTRICS	High
TERADATA	High
TIBCO SOFTWARE	High
TOSHIBA CORP	High
AMAZON	Medium
APPLE	Medium
CISCO SYSTEMS	Medium
VMWARE	High
GOOGLE	Low
HEWLETT-PACKARD CO	Low

Source: BofA Merrill Lynch Global Research. * EE exposure = BofAML estimates of current sales derived from energy efficiency products, services, technologies and solutions

IT, “big data” & semis

The global boom in “big data” on the back of explosive growth in unstructured traffic (aka big data) driven by smartphones (1bn by 2015), internet users (50% of global population by 2016), and mobile traffic growth (13x growth expected in the next five years) is seeing the global IT sector emerge as a new target area in terms of energy efficiency. Data volumes are projected to grow up to 50x to 2020E (Source: IDC). This means a significant increase in electricity consumption, with the sector consuming 1.5% of the world’s energy (Source: Pike Research) and upwards of 3-5%+ of electricity in markets such as the EU, the US and Japan (Source: ACEEE). Between 2011 and 2012, power requirements grew by 63% globally to 38GW (Source: Datacenter Dynamics). Its global CO2 emissions – c.2% of the world’s total – are already on a par with the aviation sector.

Growing energy consumption and prices mean that energy costs are leading to business and capacity constraints, particularly for energy-hungry data centres. The combination of rigid, hierarchical structures in networking and storage domains in data centres and the fact that data centres are scaling up to massive sizes (10x growth) means there is an increasing need to lower power costs. Investment in data centres grew globally by 22% to US\$105bn in 2012 (vs. US\$86bn in 2011) and investment is projected to increase by a further 14.5% in 2013 (Source: Datacenter Dynamics). **We expect this to create significant opportunities for the ‘greening’ of data centres**, with the market having grown from US\$7.5bn in 2010 to US\$17.1bn in 2012. By 2016E, the market is expected to reach US\$45.4-69.7bn (Source: Pike Research, Wintergreen Research). We believe that this should benefit two larger IT trends – virtualisation and cloud computing, both of which help to improve data centre energy efficiency.

We also expect energy efficiency to become a major growth driver for the US\$117bn addressable cloud computing market, as well as virtualisation, as they can help to lower energy use and emissions by 30-90%.

We regard semiconductors as a key enabler of realising energy efficiency in the automobiles, buildings, IT, capital goods, and transport sectors – as well as aiding the business case for renewables. We believe the c.US\$300bn sector is returning to robust growth on the back of a combination of increasing demand from a gradual economic recovery, improving confidence in distribution/retail to carry more inventory, pricing recovery in sectors such as memory, and secular tailwinds from product cycles.

We believe that a number of stocks provide exposure to the theme of energy efficiency in IT through their involvement in areas such as cloud computing, consolidation, data centre design and operation, DCIM, heating and cooling, power management, thin provisioning, virtualisation, and semiconductors.

Table 67: Overview of ICT sector

Category	Equipment
Equipment	Computing, storage, networking, telecoms, media, biomedical, etc.
Edge gear	PCs, printers, faxes, phones, mobile devices, TVs, radios, SOHO modems/routers etc.
Facilities	Data centres, equipment rooms, telephone central offices (COs), engineering cores, research labs, network and television operating centres (NOCs & TOCs), call centres, media studios etc.
Connectivity	Local, metropolitan, and wide area networks (LANs, MANs, & WANs), broadcast infrastructures, telephony networks, etc.

Source: BofA Merrill Lynch Global Research

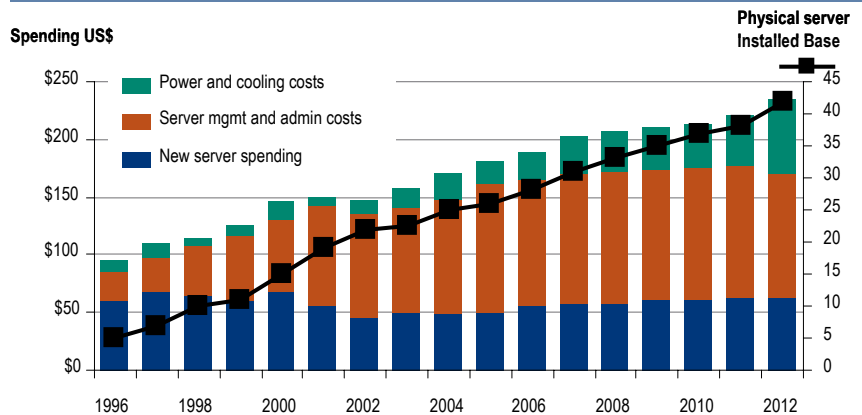
IT & energy efficiency, cost is key driver

While one might not expect the IT sector to be at the forefront of the drive to increase energy efficiency, rising energy consumption and costs have placed efficiency high up on corporate agendas. The sector as a whole – and data centres in particular – are facing growing challenges from energy costs, capacity constraints and security and supply.

25-75% of energy costs in commercial buildings

ICT systems typically account for 25% of direct electricity use in commercial office buildings. For energy-inefficient buildings or locations with a high density of IT equipment, such as data centres, this figure may be as high as 60-75%.

Chart 142: Worldwide IT spending on servers, power, cooling & management administration



Source: IDC

Emissions will exceed those of airlines

ICT's increasing energy consumption means rising CO2 emissions, with the sector now approaching 2-2.5% of total global carbon emissions, equivalent to the global aviation industry. For the US, EU and Japan, the number is closer to 5-6% and is growing at a double-digit pace. The industry's carbon footprint is expected to triple to 2020 (vs. a 2002 baseline), with the boom in data centres, mobile phones / smartphones, PCs / laptops / tablet ownership, broadband uptake and ICT infrastructure.

Table 68: ICT sector's emissions

	Emissions 2007 (MtCO2e)	% 2007	Emissions 2020 (MtCO2e)	% 2020
Data centres	116	14%	257	18%
Telecoms infrastructure & devices	307	37%	358	25%
PCs & peripherals	407	49%	815	57%
Total	830	100%	1,430	100%

Source: Smart 2020, Greenpeace; BofA Merrill Lynch Global Research

Recession upping the focus on efficiency

The debt crisis and the threat of a double-dip recession have stalled the expected return to growth in IT spending. The difficult operating environment means companies are placing increased focus on energy efficiency as a way of cutting costs and expanding their businesses. In particular, many companies are looking at third-party data centre outsourcing and the cloud, preferring this to the capex involved in building up their own data centres and the huge opex implications

(equipment, space, uninterruptable power, energy costs, engineers, security, insurance, maintenance, high-capacity communication links, etc.).

Moving up the COO/CIO agenda

In 2012, an estimated 80% of industrial and 72% of commercial organisations' IT decision-makers polled said that their companies had an energy reduction goal, while 72% and 63% had set goals for carbon reduction. (Source: Institute for Building and Efficiency) – a significant increase from an estimated 45% in 2007 (Source: IBM & EIU). Energy cost savings and government and utility incentives ranked as the top motivators for energy efficiency decisions. The key driver of the growing focus on efficiency is the rise in server management and administration costs, along with power and cooling costs.

But cost is still an issue

However, in 2012, 26% of IT decision-makers said that a lack of funding to pay for improvements was the greatest obstacle to pursuing energy efficiency at their organisations, despite the cost trends (Source: Institute for Building and Efficiency).

Data centres, emissions growing faster than airlines

It is one small but invisible step from Facebook, Outlook, Twitter and YouTube to 2,718+ data centres (Source: Data Center Map), as well as the cloud, storing and making data instantaneously available to consumers, governments and corporates. With the world's digital output set to grow 50x from 2010 to 2020 (Source: IDC), the data centre boom will continue, with the facilities consuming an increasing proportion of global energy and having an ever-larger carbon footprint.

US\$45-69bn green data centre opportunity

Investment in data centres grew globally by 22% to US\$105bn in 2012 (vs. US\$86bn in 2011) and investment is projected to increase by a further 14.5% in 2013 (Source: Datacenter Dynamics). We anticipate that this will create significant opportunities for the greening of data centres, which could become a US\$45-69bn market by 2016E (Source: Pike Research, Wintergreen research).

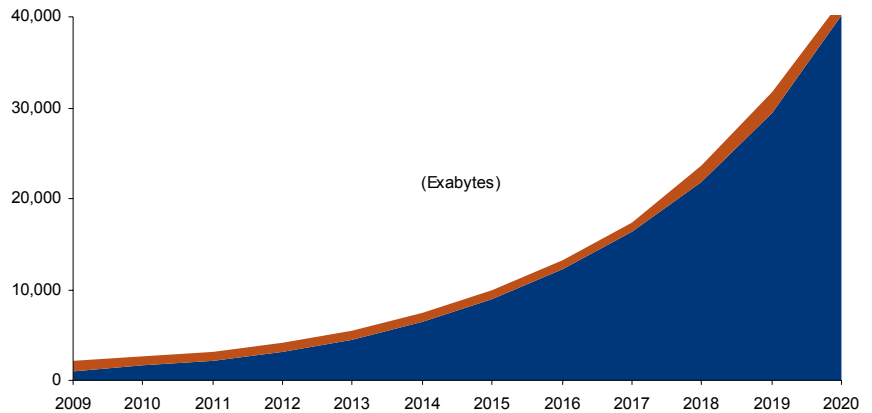
Big data, 50x increase by 2020

Thanks to the megatrend of digitalisation over the past two decades, driven by Moore's Law and the rapid advancement in microprocessors, storage and communication technologies, the amount of digital information that is being generated, stored, processed and analysed each year is increasing at an exponential rate. With digital content doubling every two years (estimated at 1 zetabyte in 2012) and an increasing number of connected devices, more enterprises are embracing big data to grow their businesses, inadvertently expanding the surface area for hackers to target. On the flip side, new big data analytics capabilities that provide better intelligence can equip security experts with tools to stay ahead of emerging threats.

Cross Reference - for further information on data centres, see our Server & Enterprise Software's teams research

[Server & Enterprise Software, 09 January 2012](#)

Chart 143: The digital universe – 50-fold growth from the beginning of 2010 to 2020



Source: IDC's Digital Universe Study, sponsored by EMC, December 2012

According to IDC, the world's total digital output was about 130 exabytes in 2005 and will grow to around 40,000 exabytes in 2020, i.e., a 300x increase. (1 exabyte = 1,000,000,000 gigabytes). IDC predicts that from now until 2020, the digital universe will double about every two years.

Total world's digital information has expanded rapidly:

- 2006: 0.18 Zettabytes
- 2010: 1.2 Zettabytes
- 2020: 35 Zettabytes

1 Zettabyte = 1,000,000,000,000 Gigabyte

Volume growth is driven by the proliferation of data sources

The rapid growth in the digital universe is driven by multiple factors – the explosion of internet applications tracking every single click and page view for each user, the proliferation of digital video recorders, digital cameras, mobile phones, sensors and RFIDs, all generating huge amounts of real-time data constantly, the analogue to digital conversion in all types of electronics and communications devices, as well as the enterprises in various vertical industries such as financial services, media, telecommunications, and transportation, which are increasingly capturing, processing and analysing all sorts of business data about customers, products, transactions, inventory management, logistics, etc.

Big data poses multiple challenges

Big data poses a complex problem because it involves new challenges across four main dimensions.

Table 69: Big data challenges

Challenge	Overview
High Volume	data volume is growing exponentially, multiplying tenfold every five years
High Velocity	machines and computers are generating data in constant streams at dizzying speed
High Variety	incredibly rich variety of data sources and data types
High Complexity	managing, understanding, correlating and drawing useful information from the immense variety of data sets is a daunting computer science challenge

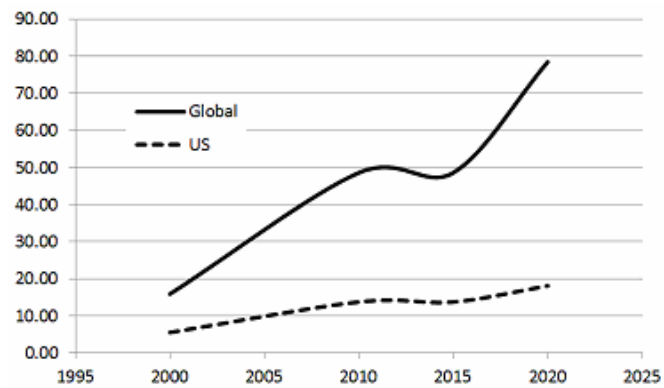
Source: BofA Merrill Lynch Global Research

Data centre boom

The growth in big data has seen an associated boom in data centres – facilities used to house computer systems and associated components (i.e. telecommunications and storage system, redundant / backup power supplies, redundant data communications connections, cooling, and safety and security devices). It is estimated that there are currently at least 2,718 co-location data centres in 90 countries globally (Source: Data Center Map) – and these figures could be on the low side given uncertainty over the number of corporate data centres.

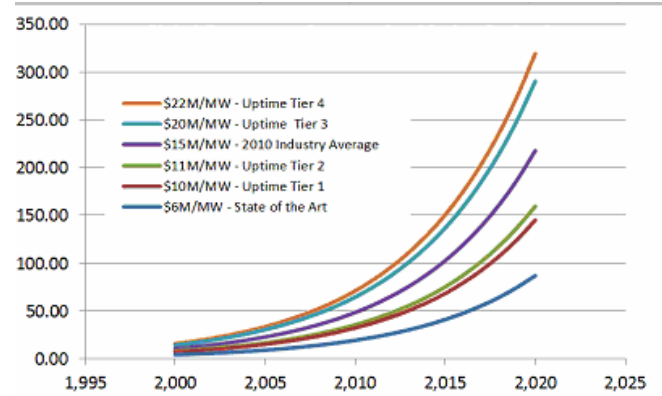
18 April 2013

Chart 144: Projected annual data centre construction market size (\$bn)



Source: Microsoft

Chart 145: Global data centre construction market projection



Source: Microsoft

Cross Reference

[US Semiconductors, 07 February 2013](#)

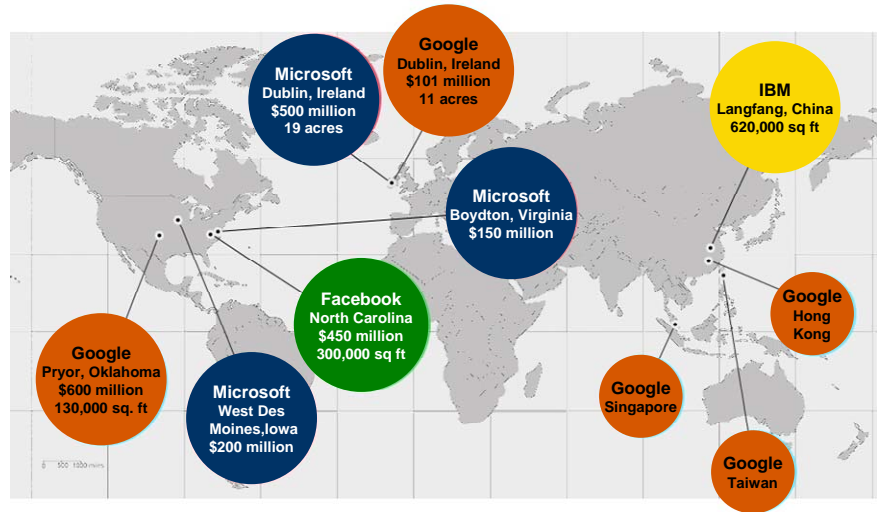
Big data, mobile traffic explosion driving new data centre

The traditional data centre architecture is being challenged by the explosive growth in unstructured traffic (aka big data) driven by smartphones (1bn by 2015), internet users (50% of global population by 2016), and mobile traffic growth (13x growth expected in next 5 years). Even though computing power (servers) has become more flexible through virtualization, the networking and storage domains in a data centre still remain stuck in rigid, hierarchical structures. Second, as data centres scale to massive sizes (10x growth), there is increasing need to lower power costs, simplify CPU design, and match compute power to workloads. These trends are creating disruptions and opportunities among old/new players

Big data centres are getting bigger

Data centres keep getting bigger – and spending more money on servers, storage, and networking. According to projections by Gartner, in 2010 about 2% of data centres worldwide comprised 52% of total floor space and 63% of total spending on hardware. By 2015, Gartner estimates that the top 2% of data centres will make up 60% of aggregate floor space and 71% of server, storage, and networking spending across all of the data centres in the world. Global demand for data centre “white space” – the area in a data centre which houses the IT equipment – grew by 8.3% in 2012 from 24mn m² to 26mn m². However, it could see a sharper rise (19.2%) to 31mn m² in 2013 (Source: Datacenter Dynamics).

Chart 146: 2012 data centre expansion plans



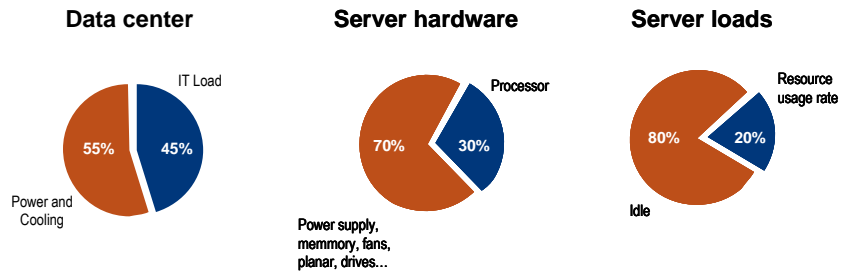
Source: Online Tech

55-80% of energy use goes towards power consumption

The boom in numbers and size has important implications for energy use. It is commonly estimated by industry that less than half of the power used by typical data centres is for IT equipment (i.e. servers, storage, and network). The other half goes towards supporting associated infrastructure (i.e. chillers, humidifiers, computer room air conditioners (CRAC), power distribution units (PDU), uninterruptible power supplies (UPS), lights, and power distribution). The primary source of energy consumption is powering the necessary cooling systems to keep the processors from overheating.

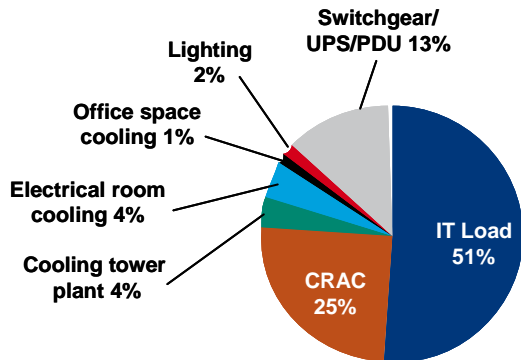
The current data centre ratio is typically 45% to power IT equipment and 55% to power associated equipment. The ratios are even further imbalanced for server hardware because of inefficient hardware and server loads owing to low utilisation rates (i.e. up to 80% of equipment / investment is being “wasted”).

Chart 147: Energy use in a typical data centre



Source: IBM

Chart 148: Energy consumption profile of a data centre



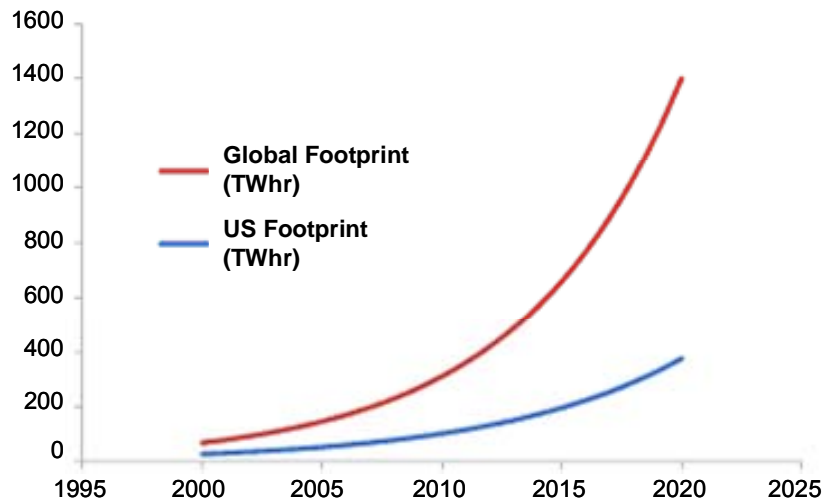
Source: Schneider

Energy use grew by 63% in 2011-12

Data centres are commonly estimated by IT companies to consume anywhere between 1.5% and 2%+ of all global electricity. Between 2011 and 2012, global power requirements grew by 63% to 38GW (vs. 24GW in 2011 and 12GW in 2007) (Source: DatacenterDynamics 2012 Global Census). This is raising serious energy- and cost-related concerns:

- **Increasing cost of energy** – While the cost of a kW of electricity has risen only slightly in recent years, the cost of operating servers has increased significantly. This is attributable to growth in server energy consumption outpacing growth in the associated utility cost – on the back of virtualisation and increasing virtual image densities.
- **Power capacity running out** – Corporates are facing growing challenges in terms of deploying additional power-hungry servers as utilities' power feeds are at capacity, especially in major urban areas.
- **Cooling capacity running out** – With many data centres now 10 or 20 years old, heat density often exceeds their original design (i.e. 2-3 kW of cooling per rack vs. today's requirement for 20-30 kW/rack).
- **Physical capacity running out** – The ongoing addition of new projects and applications online – and their images, servers or storage subsystems – is rapidly filling up data centre physical space and posing expensive capex challenges (Source: IBM).

Chart 149: Projection of data centre electricity use



Source: Microsoft

Industry-like energy use & emissions profile

The energy use and emissions profile for data centres more closely resembles industry than commercial buildings. Data centres are energy-intensive, requiring much higher levels of power and cooling than buildings where the focus is on the materials used in construction. In fact, data centres can be 40x more energy-intensive than office buildings, meaning that they more closely resemble industrial facilities (Source: Schneider).

Some positive signs on efficiency

According to a Datacenter Dynamics study, 2012 saw an increase in average kW per server rack. Globally, the proportion of high-density racks (>10kW per rack, which are more energy-efficient) as a proportion of total racks increased from 15% in 2011 to 18% in 2012. The percentage of medium-density racks (5-10kW per rack) increased by a larger proportion, from 30% to 33%.

But results are still poor - PUE of 1.9-2.9

Average data centre efficiency in the US as measured by average PUE (Power Usage Effectiveness) could be as poor as 2.9 – with lower scores better and the Ideal score at close to 1.0. A PUE of 2.0 means that for every 2w of electricity supplied to the data centre, only 1w reaches the computing equipment (Source Digital Reality Trust). An April 2013 survey of 300 IT decision-makers at large corporations in North America (each with annual revenues of at least US\$1bn or 5,000+ employees) found that data centres might be much less efficient on average than previously thought. The survey also showed that 20% of respondents reported having a PUE of less than 2.0, while 9% had a PUE of 4.0 or greater. Reasons for the high PUE include old(er) designs and equipment, under-utilized assets, design and operating issues, and the overall complexity of data centre management. Previous studies, such as 'The Uptime Institute Survey' (2012) of 1,100 data centre users, reported an average PUE of 1.8-1.89 (vs. 2.5 in 2007) and the US EPA put the average PUE at 1.91 in 2009.

Carbon footprint in line with aviation

The US EPA estimates that servers and data centres are responsible for up to 1.5% of total US electricity consumption, or roughly 0.5% of US GHG emissions. The EPA had originally estimated that data centres would overtake airlines as a source of CO2 emissions by 2020, but there is a growing feeling that the big data boom may see this date brought forward. That said, future estimates must be accounted for in the light of efficiency and cost gains, technological shifts, and new business models.

Key factors impacting carbon footprint

- 1) **Location** – Geography and weather influence energy consumption, with greater consumption in locations with extreme temperatures and humidity levels. As such, Canada, Finland, Sweden and Switzerland are all pushing to attract data centres. The local energy mix (coal vs. nuclear vs. NG vs. coal vs. renewables) will also significantly affect the carbon footprint and the frequency of avoided emissions (i.e. average activity of peaker plants and potentially higher carbon footprint).
- 2) **IT load** – This represents how much power the IT equipment itself consumes including hardware / business architecture (servers, routers, computers, storage devices, telecommunications equipment) and the fire, security and monitoring systems that protect them. The higher the load, the more power needed to keep the system running and the higher the carbon footprint.
- 3) **Electrical efficiency** – Typically, data centres' physical infrastructure is oversized in order to build in a margin for error in terms of capacity. This results in underutilisation, which can be tackled by solutions like design, modular and scalable IT and physical infrastructure (i.e. "pay as you grow"), advances in capacity planning software and technologies (Source: APC)

Average data centre efficiency in the US as measured by average PUE (Power Usage Effectiveness) could be as poor as 2.9 – with lower scores better and the ideal score at close to 1.0 (Source Digital Reality Trust).

A US data centre's energy source "mix" may be 60% coal, 20% oil, 10% natural gas and 5% hydro and 5% wind farms - while a data centre in central France would draw 95% of its electricity from nuclear (Source: APC)

Greater scrutiny from regulators on the horizon

We expect an increasing number of jurisdictions to be looking to improve energy efficiency and cut emissions in the ICT sector. While such efforts have largely been voluntary to date, we believe it is only a matter of time before binding standards are brought in.

UK's CRC Energy Efficiency Scheme

The UK Environment Agency's CRC Energy Efficiency Scheme (2008) is a mandatory scheme designed to tackle CO2 emissions not already covered by Climate Change Agreements (CCAs) and the EU Emissions Trading Scheme. Companies that consume more than 6,000MWh/year of half hourly metered electricity during 2008 – encompassing many data centre operators – qualify for full participation and register with the Environment Agency. The scheme features an annual performance league table that ranks participants on energy efficiency performance.

EU code of conduct for data centres

The EU Code of Conduct was created in response to growing data centre energy consumption. It aims to raise awareness and encourage data centre operators to reduce energy consumption in a cost-effective manner by improving their understanding of energy demand and recommending energy-efficient best practices and targets. The focus is on reducing energy loss by using efficient hardware, cooling, cold aisle containment, and PUE (power usage effectiveness) as a KPI. The European Commission is also piloting methodologies quantifying the environmental footprint of ICT products, networks, services and organizations.

US EPA's Energy Star

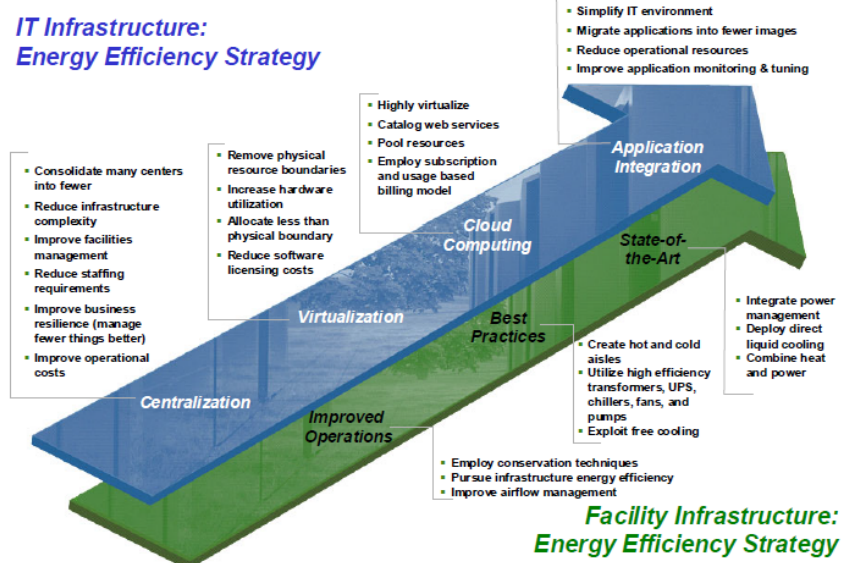
The US EPA's Energy Star program – which gives a rating for qualified energy-efficient products and equipment – first established a rating for data centre products in 2010. All Energy Star-labelled data centre products come with an associated "Power and Performance Datasheet" that lists product information and detailed test results. The EPA announced an update in January 2012 which added UPS, network gear and storage to its rating spec processes and will be finalised in 2012/13. Energy Star has teamed up with Standard Performance Evaluation Corporation to develop an active power performance measurement tool called SERT, which will offer details about the energy performance of servers running common workloads.

Greening data centres - a US\$45-69bn opportunity by 2015-16E

With the energy use and cost factors, along with GHG emissions, all becoming serious bottom-line issue, the ICT sector is looking more and more to energy efficiency solutions for data centres. This transformation increasingly encompasses the sector's latest developments in design, technology and operational best practice principles. Investment in greener data centres has grown rapidly from US\$7.5bn in 2010 to US\$17.1bn in 2012. By 2016, the market is expected to reach US\$45.4-69.7bn (Source: Pike Research, Wintergreen Research)

The European Commission also acknowledges those data centre operators with efficient operations with IBM, for instance, being recognised for having 27 energy-efficient data centres, the largest for any one company

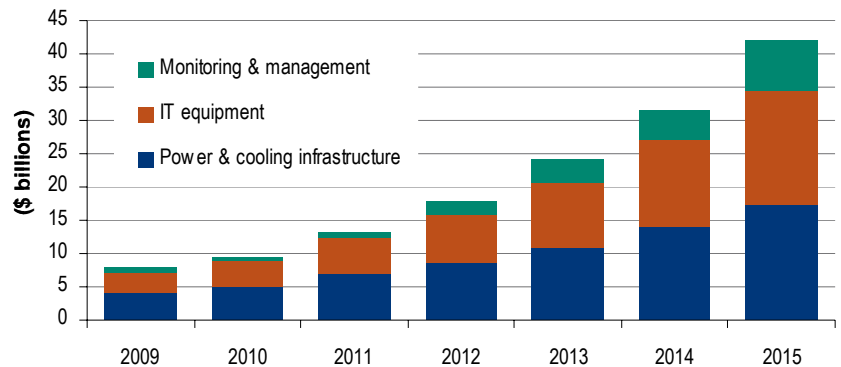
Chart 150: Energy efficiency options across facilities and IT



Source: IBM

The US is projected to be the largest single market, with revenues expected to grow to US\$13.8bn by 2015. Power and cooling infrastructure solutions are expected to account for the largest portion of the green data centre market opportunity (c.46% of the market by 2015), followed by efficient IT equipment (c.41%) and monitoring and management (c.14%) (Source: Pike Research).

Chart 151: Green(er) data centre revenue estimates to 2015

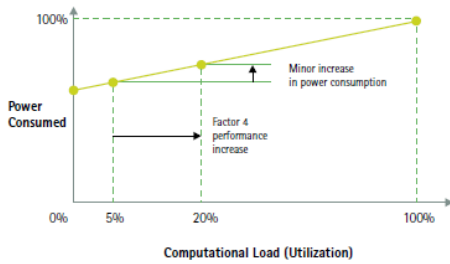


Source: Pike Research

Energy efficiency solutions

With today's energy efficiency best practices, 20-50% energy savings are possible, extending the life and capacity of existing data centre infrastructure, significantly reducing opex costs, and avoiding millions of metric tons of carbon emissions (Source: US EPA). Among the solutions gaining increasing traction are the following:

Chart 152: Relationship between server utilization & power consumption



Source: Accenture

a) Upgrading & consolidating technology

Table 70: Upgrading & consolidating technology

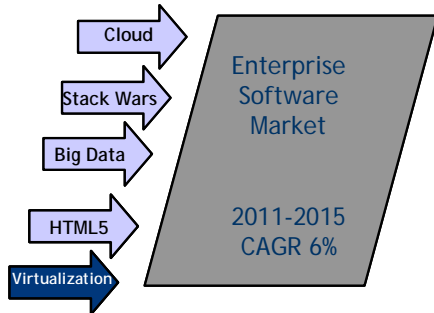
Energy efficiency measure	Overview/benefits
Virtualisation	By consolidating multiple, independent servers to a single physical server, those servers can operate more efficiently and reduce energy costs by 10% to 40%.
Decommissioning un/under-utilised servers	15% to 30% of the equipment running in data centres consumes electricity without doing any computing.
Consolidating lightly used servers	A typical server's utilization is about 5% to 15%, yet it draws full power.
Organising and improving stored data	Storage utilisation averages only around 30%. It is common for organizations to have 20 or more copies of the same data, wasting storage space.
Investing in technologies that use energy more efficiently	An ENERGY STAR qualified server uses 30% less energy than a conventional server.

Source: BofA Merrill Lynch Global Research, company and government sources

Cross Reference

[Software, 02 May 2012](#)

Exhibit 1: Virtualization is emerging as a key driver of enterprise spending



Source: BofA Merrill Lynch Global Research

Virtualization emerging as a key driver of enterprise spending

Virtualization is the optimization and delivery of applications regardless of user location or equipment, by driving higher utilization rates or by repurposing existing assets and resources. Virtualization connects and harnesses many elements of IT, including semiconductors, data network, data centres, storage, and software.

Our US Server & Enterprise Software team believes that virtualization will be the next killer platform/control point in the IT data centre. In our view, it will be disruptive enough to enable new leaders to challenge the incumbents. This is similar to the rise of platforms like operating systems (OS) and databases (DB) that drove Microsoft and Oracle.

A brief background on virtualization management

Approximately 50% of workloads are virtualized – and our US Server & Enterprise Software team believes that the next phase of growth for companies like VMware will be defined by virtualization management.

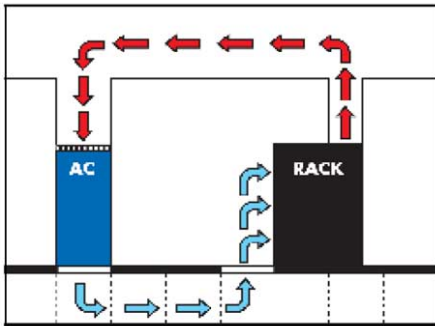
Our US Server & Enterprise Software team believes that virtualizing the servers is just the first step in the journey towards the software defined data centre. Cloud computing requires all computer, storage and networking resources to be virtualized, controlled and managed through software. The phrase “Software Defined Data Centre” captures exactly this new idea in terms of how modern data centres should be built and operated to enable cloud computing. Our US Server & Enterprise Software team believes the industry will slowly evolve its data centre structure to embrace the idea of software defined data centres.

Cross Reference

[VMware Inc., 14 December 2012](#)

Our US Server & Enterprise Software team believes virtualization management is the next major growth opportunity for VMware

Chart 153: Managing air flow



Source: Oracle

b) Managing air flow

Table 71: Energy efficiency benefits of managing air flow

Energy efficiency measure	Overview/benefits
“Hot Aisle/Cold Aisle” layout	Fronts of the server racks face each other and the backs of the server racks face each other - reduces mixing of hot and cold air to improve efficiency.
Contain / enclose server racks	Using flexible strip curtains or rigid enclosures reduces mixing the cold supply air with the hot exhaust air
Review general air flow improvement tips	Examples of how less leakage helps direct more cold air to the equipment that needs cooling include: blanking panels decrease server inlet air temperatures and increase the temperature of air returning to the CRAC, and improve operational efficiency; using structured cabling to avoid restricting air flow to servers; installing grommets to seal areas where cables enter and exit plenums (such as a raised floor).
Free cooling	Increasing number of data centres are piping outside air in to cool equipment (air-side economization). Traditional data centre cooling systems recirculate air, moving hot air exhausted from server racks (up to 115°F) into air-cooling units and then pumping the cool air back to the servers. For new data centres, the potential savings of free cooling are significant, and depending on the outside temperature; one can either avoid using mechanical cooling systems for weeks at a time or all together
Water / liquid cooling	Water cooled systems are gaining in popularity as 1l of water can absorb c.4,000x more heat than the same volume of air. Chilled building water can feed water cooling units (WCUs) – and heat produced by the system can be passed to building water - lowers temperatures & lower power consumption

Source: BofA Merrill Lynch Global Research, , company and government sources

c) HVAC

Table 72: Energy efficiency benefits of HVAC

Energy efficiency measure	Overview/benefits
Replacing chiller or UPS systems	Replacing 15Y+ old UPS equipment with best in class equipment means up to 70% greater energy efficiency; new chillers can improve efficiency by up to 50%
Adjust temperature and humidity	The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) established new recommended temperature and humidity ranges at the inlet of the server in 2008. However, many data centres set their temperatures as low as 55°F (when the recommended range is 65°F to 80°F) and keep very tight controls on humidity. Data centres can save 4% to 5% in energy costs for every 1°F increase in server inlet temperature.
Retrofit AC with variable speed fan drives	Retrofit kits for CRACs have a two year payback by being able to adjust fan speed to accommodate changing cooling loads in the data centre.
Install an air-side economizer	Bring outside cooling air into a building. Because data centres must be cooled 24/7, 365 days per year, air-side economizers may even make sense in hot climates, where they can take advantage of cooler evenings and winter air temperatures to save 60% on cooling.
Install a water-side economizer	Using the evaporative cooling capacity of a cooling tower van produces chilled water during the winter months. During water-side economizer operation, costs of a chilled water plant are reduced by up to 70%.

Source: BofA Merrill Lynch Global Research, company and government sources

d) Reducing power consumption

Table 73: Energy efficiency benefits of reducing power consumption

Energy efficiency measure	Overview/benefits
Hardware solutions	Power conversion and distribution; temperature, humidity and atmospheric pressure sensors; static power save, new monitoring systems/functions; HVDC

Source: BofA Merrill Lynch Global Research, company and government sources

e) Data centre infrastructure management

Table 74: Energy efficiency benefits of data centre infrastructure management

Energy efficiency Overview/benefits measure

DCIM Software technology that can allocate power, cooling and space to individual assets in real time; enables operators to visualise, model, plan, control, report and estimate energy use

Source: BofA Merrill Lynch Global Research, company and government sources

Need to better understand KPIs

Power Utilization Effectiveness (PUE) has been promoted by industry – and by multi-stakeholder initiatives such as the Green Grid – as the best-practice KPI (key performance indicator) to measure a facility’s energy efficiency. PUE is a ratio of all the electricity that a facility consumes to the electricity used by the IT equipment it houses. A PUE of 1.0 indicates that a data centre’s lighting, power, and cooling systems consume no power and its power distribution system is perfectly efficient (vs. most data centres, which have a PUE of 2.0-3.0 – i.e. ancillary systems and losses consume more electricity than the servers). While it is an excellent measure of facility-related efficiency, there is also a move to understand IT asset-/environment-related efficiency via measures such as:

- Asset efficiency – comparing CPU utilization vs. power usage at the individual device level, to determine which asset is delivering business value at the highest efficiency.
- IT efficiency – comparing the energy going into business-related IT assets such as servers vs. non-business related assets such as storage and switches (Source: WWPI)

Asset efficiency can be measured by:
Work per kw = realised business output per asset / energy consumed by asset

IT efficiency can be measured by:
PUE of IT = IT load / business output load

Table 75: Recent new green data centres

Company	Location	PUE	Energy efficiency overview
Facebook	Prineville, Oregon, USA	1.05 to 1.10	- Free cooling (cool dry eastern Oregon desert air); evaporation room (dry air for low low-power evaporative cooling when outside temperatures are high)
FedEx	Colorado Springs, Colorado, USA	1.28	- Free cooling (cool, dry Rocky Mountain air) for 5,000 hours/y or 57% of time
Google	Hamina, Finland	1.14*	- Uses seawater for cooling: heat exchangers cool the servers, and the warm wastewater is mixed with seawater before it's returned to the Gulf of Finland to minimise thermal pollution
Harris Corporation	Harrisonburg, Virginia, USA	1.36	- Recycles cooling water to irrigate the data centre's 4.5 acre grounds (closed-loop condenser cooling system uses UV light & electrical pulses rather than chemicals to control corrosion, scale and biological contamination).
Hewlett-Packard	Fort Collins, Colorado, USA	1.15	- Free cooling and evaporative cooling; environmental sensors that feed a data analytics system for resource management; plastic sheets above server racks prevent cold air fed into the servers from mixing with hot air exhausted from the servers
IBM	Auckland, New Zealand	1.6**	- Uses environmental monitoring and a power management system that measures power, water and diesel use in real time; free cooling: outside air and rainwater captured in cooling towers
Tieto	Espoo, Finland	1.2 to 1.3	- Uses waste heat to heat 1,500 area homes via neighbouring cogeneration power plant
Vantage	Santa Clara, California, USA	1.29	- LEED Platinum certification
Verne Global	Reykjanesbaer, Iceland	1.2***	- Carbon-neutral operations: powered by geothermal & hydroelectric energy; free cooling (cool dry Icelandic air)

Source: Wired, companies, *average of Google's 5 MW and larger data centers; **annual maximum level; ***testing phase data

Cloud computing

We are bullish on cloud computing and remain vocal about its significance, market opportunity and energy efficiency credentials as it heads to the mainstream. In a nutshell, cloud computing refers to applications and services offered over the internet – with services provided from data centres all over the world, which are collectively referred to as the "cloud". It delivers computing applications, platforms and infrastructure as a service rather than a product and our Tech team’s bottom-up analysis shows that it has become a US\$117bn

While the current balance is 70:30 in favour of owning your own data centre, the picture is changing: the theoretical breakeven point for building your own versus outsourcing is 400 or more physical servers or 10,000 virtual servers (Source: C4L)

addressable market. We anticipate that a growing number of players will look to outsource their data centre-related activities to the cloud, whose potential large scale and energy efficiency best practice adoption in data centres could reduce energy use and CO2 emissions by 30-90%.

The lay of the cloud: three main segments

Three distinct market segments are enabled by the cloud: apps (called either OnDemand or SaaS for Software-as-a-Service), platforms and infrastructure. In addition, other technology companies act as enablers. Some technology vendors fall into multiple cloud segments as well. Google and Microsoft are notable for being in all three cloud segments, while Amazon is in two (platform and infrastructure), as is Salesforce.com (apps and platform). IBM and EMC are in one segment, infrastructure, but are also enablers.

1) Apps as a Service

On Demand Application (aka Application as a Service and Software as a Service) is an application delivery model where software code and associated data are hosted centrally in the cloud and are accessed by users typically through a web browser over the internet. There are two essential criteria:

- It is paid for on a subscription basis; and
- The software is hosted by the vendor and accessed by the customer over the internet.

On Demand has become a common delivery model for enterprise applications, including Customer Relationship Management, Human Resource Management, Accounting and Finance, and Collaboration.

The pure OnDemand business model, which involves *both* subscription pricing *and* hosted deployment, is the opposite of the traditional software model. Prominent players include Salesforce.com, RightNow, Taleo, NetSuite, Concur, Omniture, and Google Apps. Arguably the market leader, Salesforce.com, emphasizes that it is not about selling software. OnDemand is often also referred to Software-as-a-Service, or SaaS, but using the word software in descriptions of the OnDemand model can be misleading, in our view. OnDemand is really about providing a service, not selling software.

2) Platforms as a Service

Some OnDemand companies initially started out providing apps as an OnDemand service, but have since built platforms that can be used to deploy new apps, provided either by partners or the customers themselves.

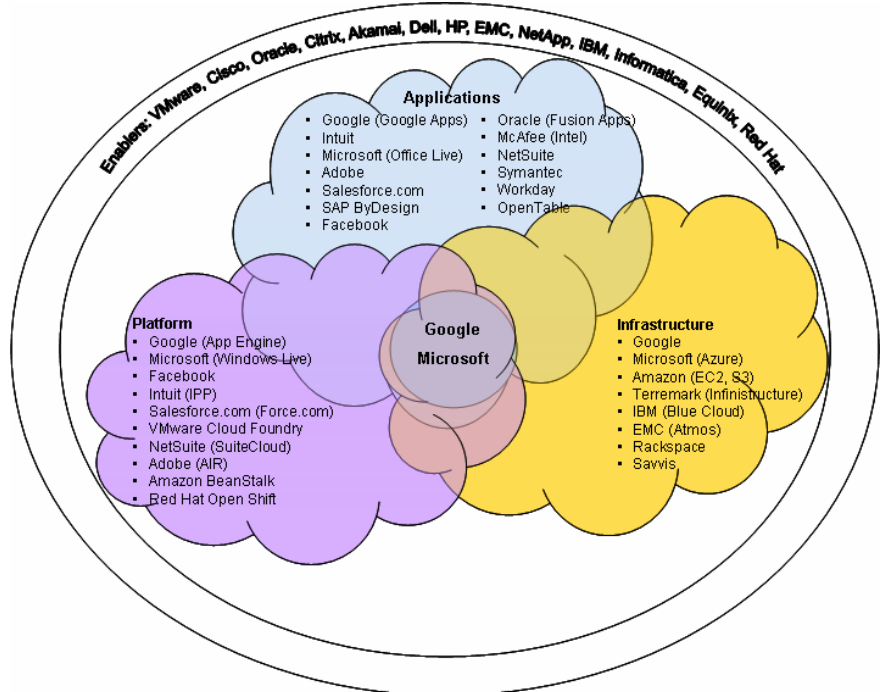
Notable platform vendors include Salesforce.com and NetSuite, which have both deployed platforms over the past couple of years. Salesforce.com's platform is called Force.com, and the company has encouraged a whole ecosystem of developers which have developed multiple apps that are available on the Salesforce.com infrastructure, deployed over the internet. NetSuite has something similar, called SuiteCloud.

Other large vendors – Google with its App Engine, Amazon with its EC2, VMware with Cloud Foundry and Microsoft with Windows Azure – have also deployed platforms. Smaller vendors, such as Bungee Labs and Corent, provide cloud-based development tools to create apps that are deployed over the internet.

3) Infrastructure as a Service

Infrastructure vendors provide raw physical capacity for cloud computing. This may include any combination of hosting, a development environment, and/or storage. As an example, with managed hosting (e.g., through IBM, RAX, Savvis or Terremark), customers get all their infrastructure provided to them and are responsible only for the apps sitting on top, relieving them of the infrastructure burden. Other alternatives are vendors (e.g., Google) which allow you to build your own apps using their development environment, and then have them hosted on their service through the cloud. Similarly, Amazon provides cloud storage with its S3 offering.

Chart 154: Cloud vendors currently fall into three core categories



Source: BofA Merrill Lynch Global Research

Expecting cloud to further spread across tech food chain

Cloud computing as a new technology paradigm has crossed the chasm and reached the mainstream. In 2011, Salesforce.com diversified its SaaS offering beyond CRM (Customer Relationship Management) to HCM (Human Capital Management) through the acquisition of Rypple. Oracle acquired SaaS company, RightNow, and announced public cloud offerings based on Fusion apps for CRM and HCM that were launched in early 2012. SAP acquired HCM leader SuccessFactors while IBM acquired retail SaaS provider DemandTec. RedHat made a number of technology acquisitions which formed the basis of its own IaaS (Infrastructure as a Service) and PaaS (Platform as a Service) offerings. VMware also entered the PaaS market with its CloudFoundry initiative.

If 2012 will be remembered as the year of the SaaS, 2013 will see a shift to PaaS, however we expect cloud computing adoption to continue to accelerate. Competition in both the SaaS and PaaS arenas should escalate with more acquisitions, as well as new entrants and new products emerging.

Cloud computing caters to companies' need to service the growth in data traffic but keep expenses in check. It allows users to access computer programs

Amazon's cloud services now run as much as one percent of the internet. (Source: Wired)

through a web browser without installing them on a PC. It also enables companies to lease capacity from external cloud providers, instead of building it locally. This is enabled by advancements in virtualization, parallel processing and multi-core, and requires a new breed of products that innovate at all segments (Software, Hardware, Networking and Internet). We identify the best-positioned companies in the software sector as: Salesforce.com, Microsoft, Rackspace, Red Hat, Intuit, and VMware.

Bottom-up analysis points to US\$117bn addressable market

We have conducted a bottom-up approach to sizing the cloud computing market, taking into account the various buckets of cloud spend – Applications as Service, Infrastructure as Service and Platform as Service. We estimate that application software consisting of various categories (like email, HR, T&E, finance, CRM, security, analytics and collaboration) has a target addressable market (TAM) of US\$51.2bn. We estimate the TAM for the infrastructure market at US\$39.2bn and the platform software market at US\$27bn. Taken together, our bottom-up approach values the overall cloud market at approximately US\$117bn.

Salesforce.com, Microsoft and Google appear well positioned in all three buckets. Large addressable segments and key players are collaboration (US\$18bn; Salesforce.com), email (US\$9.6bn; Microsoft, Google), human capital (US\$3bn; SAP/SuccessFactors, Taleo, Workday), finance (US\$1.3bn; Intuit), infrastructure services (US\$10bn; Amazon, Rackspace), and platforms (US\$26bn; Salesforce.com, Microsoft)

Chart 155: Using a bottom-up approach, we estimate the total Cloud TAM at ~US\$117bn

Software Category	Sub-Category	TAM est	Description	Potential Winners
		(\$ billions)		
Applications			We have looked at several categories of Application software and identified a TAM for each category.	
	Collaboration	\$19.1	- Social Networking and collaboration tools like Chatter, GoToMeeting	Salesforce.com, Citrix
	Email + Office Productivity Apps	\$10.0	- Cloud based email offerings like Gmail and office productivity apps like Office WebApps	Microsoft, Google
	CRM	\$9.6	- Cloud based CRM applications like Sales Cloud and Service Cloud from Salesforce.com and customer service from RightNow	Salesforce.com, RightNow
	Security	\$4.9	- Security as a Service offerings	Symantec, Qualys
	HCM	\$3.6	- Cloud based HR, talent management, performance management and recruiting tools	SuccessFactors, Taleo, Workday
	Finance & Accounting	\$1.5	- Cloud based financial and accounting apps like QuickBooks Online or Business ByDesign	Intuit, Oracle
	Analytics	\$1.2	- Web Analytics software that mines user data	Adobe (Omniiture)
	Travel & Expense	\$1.4	- Cloud based Travel and Expense management tools	Concur
	Total	\$51.2		
Infrastructure			We have split the Cloud based Infrastructure opportunity in two buckets	
	Private Cloud Infrastructure	\$29.2	- Complete stacks offerings by infrastructure companies to deploy Private Clouds within their internal data centers	Cisco, IBM, VMW, EMC, Red Hat
	Infrastructure as a Service	\$10.0	- Includes managed hosting service offerings from providers	Amazon, Microsoft, Rackspace
	Total	\$39.2		
Platform			Given that the Platform Cloud offering is still nascent, we have used the estimate from our top-down analysis here	Google, Salesforce.com, Microsoft
	Total	\$27.0		
AGGREGATE TOTAL CLOUD TAM (\$bn)		\$117.4		

Source: BofA Merrill Lynch Global Research

Notes: Please see below for details on estimates for each category

Nine themes for cloud computing

We identify nine overarching themes that we believe will become key trends over the next few years as cloud computing matures from an early concept into a

meaningful disruptive shift. These themes are closely linked to the growing data use and resulting energy use and emissions that we have discussed earlier. We also highlight companies that we believe may emerge as beneficiaries of these trends.

Table 76: We highlight nine key themes and likely beneficiaries within each theme

	Key Themes	Main Takeaways	Likely Beneficiaries
Theme 1	Platform Cloud	PaaS will likely be the most strategically important market segment for cloud computing. We are at the early stage of development, and competition is heating up. The trend is to make PaaS more open and flexible. The priority is to gain developer support and adoption, while monetization will follow further down the road.	CRM, MSFT, GOOG, VMW, RHT
Theme 2	Infrastructure Cloud	IaaS is not only providing cost savings, but also lowering the hurdle for creating new businesses and tapping into powerful computing infrastructure. Telcos are entering the space with many acquisitions.	AMZN, RAX, EQIX
Theme 3	Social Cloud	Social computing is an integral fabric of both enterprise and CRM. Companies are becoming more collaborative, leveraging social software, and marketing and customer engagement are being transformed by social networks.	CRM
Theme 4	Media Cloud	Traditional media distribution channels are ripe for "reintermediation". Netflix is becoming the reigning champ of the video cloud. Amazon is looking to be the king of all cloud-based digital media.	NFLX, AMZN
Theme 5	Database Cloud	Cloud-based database will become a fertile ground for innovations attracting both incumbents and new entrants. Alternative data management solutions (NoSQL) and data as services will become increasingly important for developers of next-generation cloud applications.	CRM, ORCL, MSFT, AMZN
Theme 6	Big Data Cloud	Huge amounts of data generated by cloud applications and social networks provide opportunities for companies to derive valuable insights into building new products and business models. Data analytics is becoming the source of competitive differentiation.	CRM, ORCL, IBM, INFA, TIBX, TLEO
Theme 7	Open Source Cloud	Lower cost, flexibility and extensibility make open source software components key building blocks for both public and private clouds. They are also embraced by developers. Key cloud players are leveraging open source model to achieve critical mass and market adoption for their offerings.	RHT
Theme 8	Mobile Cloud	Rapid proliferation of mobile devices is driving location-based services and mobile transaction capabilities using Smartphones.	GOOG, INTU, EBAY
Theme 9	Data Center Cloud	Data centres are undergoing transformations as well, with new networking architectures, virtualized networking, mega-bandwidth and more intelligent networks, virtualized storage and cloud-based storage.	EMC, JNPR, VMW

Source: BofA Merrill Lynch Global Research

in September 2012 the European Commission published the EU strategy on cloud computing, which aims to extend the use of this technology (to SMEs in particular) and could, according to their forecast, deliver cost savings of up to €600bn between 2015 and 2020 (or €300/person per year), and generate up to 2.5mn new jobs.

Lower energy use & CO2 emissions reduced by 30-90%

While the growth of cloud computing means a near-term increase in data centres, the cloud has huge potential to facilitate greater energy efficiency within data centres via large-scale implementation of practices such as dynamic provisioning, multi-tenancy, server utilisation and data centre efficiency. While large organisations can implement these efficiency drivers in their own data centres, outsourcing to public cloud infrastructure providers offers greater economies of scale to reduce energy consumption, costs and GHG emissions.

Table 77: Cloud's energy efficiency benefits

Cloud feature	Energy efficiency benefits
Reduce over-allocating of infrastructure (Dynamic Provisioning)	Forecasting and ongoing adjustment of allocated capacity avoids unnecessary over-allocation of resources and sizing close to actual usage (i.e. reduces wasted computing resources).
Share application instances between multiple organizations (Multi-Tenancy)	Sharing application instances between client organizations (tenants) flattens peak loads and reduces overhead for tenant onboarding and management.

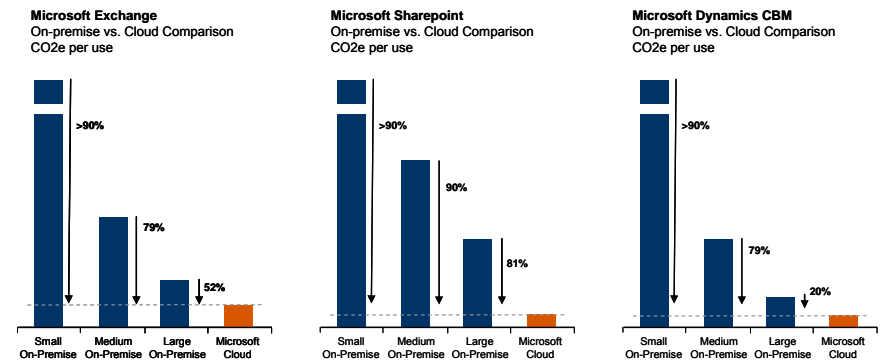
Table 77: Cloud's energy efficiency benefits

Cloud feature	Energy efficiency benefits
Operate server infrastructure at higher utilization	Large deployments of virtualized server infrastructure serving multiple tenants can balance compute and storage loads across physical servers and thus be operated at higher utilization rates.
Improve data centre efficiency (PUE)	Industrialized data centre design at scale and optimized for power efficiency reduces power wasted on cooling, UPS etc. and allows for running servers at optimal utilization and temperature.

Source: Accenture-WSP

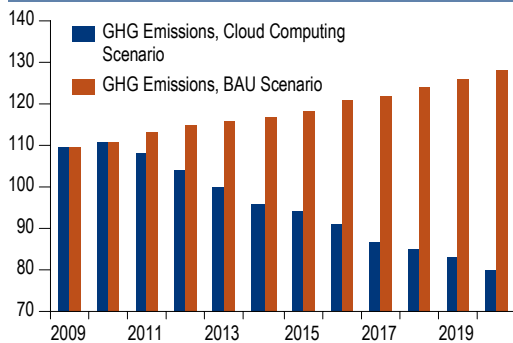
- **Accenture-WSP study (2010) shows that for large deployments of 10k+ users, Microsoft's cloud solutions can reduce energy use & CO2 emissions by 30% when compared with their corresponding Microsoft business applications installed on-premise. The benefits were more impressive for small deployments (100 users), with potential for a 90%+ energy use and emissions reduction with a shared cloud service.**

Chart 156: Comparison of CO2 emissions of cloud-based vs. on-premise delivery of 3 Microsoft applications* (↓ = estimated decrease with Microsoft Cloud)



Source: Source: Accenture-WSP. * The analysis focused on three of Microsoft's mainstream business applications—Microsoft Exchange®, Microsoft SharePoint® and Microsoft Dynamics® CRM. Each application is available both as an on-premise version and as a cloud-based equivalent. The analysis compared the environmental impact of cloudbased vs. on-premise IT delivery on a per-user basis and considered three different deployment sizes—small (100 users), medium (1,000 users) and large (10,000 users).

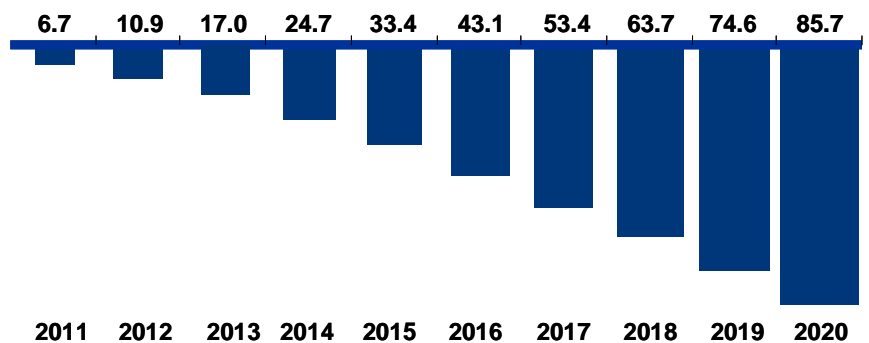
Chart 157: 39% reduction in data centre GHG emissions under a cloud scenario



Source: Pike Research

- **The Carbon Disclosure Project study (2011) shows annual energy savings of US\$12bn in the US by 2020: It used case study evidence from 11 global companies and assessed the financial benefits and potential carbon reductions for a company opting for a particular cloud computing service. The results show that by 2020, US companies with annual revenues >US\$1bn/year that use cloud computing could achieve annual energy savings of US\$12.3bn and annual CO2 reductions of 85.7mn MT of CO2/y or 200mn boe (Source: CDP).**

Chart 158: CDP model's derived net CO2 savings 2011-2020



Source: CDP

WANs account for 90% of cloud energy consumption

Wireless-access networks (WAN) account for 90% of the total energy consumption of the “wireless cloud”, while data centres consume 9%. Total energy consumption of the wireless cloud is expected to grow from 9tWh in 2012 to between 32tWh and 43tWh in 2015E (Source: The Center for Energy-Efficient Communications).

Green cloud vs. brown cloud

A number of stakeholders have been critical of the cloud’s “green” credentials, arguing that data centre operators or cloud providers need to focus on lowering their own emissions footprints. We believe that the sector has made significant energy efficiency inroads – as discussed in the section on data centres – and is increasingly looking to raise the proportion of renewables in its energy mix. That said, stakeholders remain critical that companies are not sufficiently disclosing their energy footprints and efficiency strategies and that coal remains responsible for up to 50-80% of their energy mix.

Table 78: Greenpeace’s clean cloud power report card

Company	Clean energy index	Coal	Nuclear	Energy transparency	Infrastructure siting	Energy efficiency & GHG mitigation	Renewables & advocacy
Akamai	NA	NA	NA	A	C	B	D
Amazon	13.5%	33.9%	29.9%	F	F	D	F
Apple	15.3%	55.1%	27.8%	D	F	D	D
Dell	56.3%	20.1%	6.4%	C	C	C	D
Facebook	36.4%	39.4%	13.2%	D	B	B	C
Google	39.4%	28.7%	15.3%	B	C	B	A
HP	19.4%	49.7%	14.1%	C	D	B	C
IBM	12.1%	49.5%	11.5%	C	D	C	D
Microsoft	13.9%	39.3%	26.0%	C	D	C	C
Oracle	7.1%	48.7%	17.2%	D	D	C	D
Rackspace	23.6%	31.6%	22.3%	C	C	C	C
Salesforce	4.0%	33.9%	31.0%	B	C	C	C
Twitter	21.3%	35.6%	12.8%	F	D	F	D
Yahoo	56.4%	20.3%	14.6%	C	B	B	B

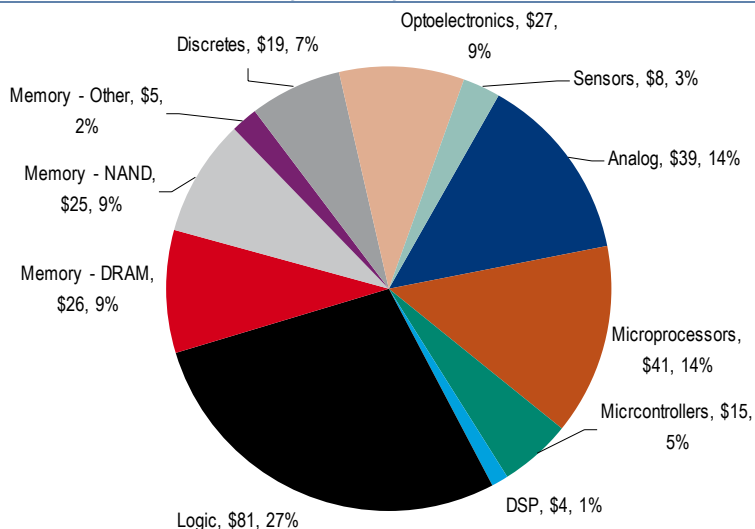
Source: Greenpeace (April 2012)

Semiconductors, cheap as chips energy savings

Semiconductors have a key role to play in improving energy efficiency at all stages of the value chain from power generation, transmission and usage to intelligent and optimised energy use in industry and by consumers. Semi chips allow us to “do more, using less”.

We expect it to be a key enabling technology to improve energy efficiency and reduce energy consumption worldwide for buildings, IT, and the transport sectors – as well as promoting the viability of renewables.

Chart 159: Semiconductor sales by product type



Source: SIA, WSTS, BofA Merrill Lynch Global Research Estimates

Table 79: BofAML semiconductor industry forecast summary

(Million)	2012E				2013E			
	Units	Y/Y %	Billings	Y/Y %	Units	Y/Y %	Billings	Y/Y %
Logic	59,954	1.5%	100,216	1.0%	67,765	13.0%	111,923	11.7%
Analog	90,503	-1.6%	39,649	-6.4%	99,429	9.9%	42,304	6.7%
MPU	495	-6.8%	41,863	-6.4%	514	3.9%	43,453	3.8%
Memory	34,752	-1.3%	57,747	-4.9%	37,662	8.4%	71,453	23.7%
Total ICs	185,704	-0.6%	239,475	-3.1%	205,370	10.6%	269,133	12.4%
Total Semiconductors	673,380	1.9%	292,984	-2.2%	720,069	6.9%	327,063	11.6%

Source: SIA, BofA Merrill Lynch Global Research estimates

Enabled 1.2% to 2.1% decline in energy intensity

The family of semiconductor-enabled technologies has been one of the leading factors behind energy efficiency gains over the past 50+ years:

- US energy intensity declined by an average 1.2% p.a. between 1950 and 1995 and further to 2.1% p.a. between 1995 and 2008.
- Savings of c.775bn kWh of electricity in the US in 2006, the equivalent of US\$69bn in business and consumer savings and 479Mt of CO₂eq abated (Source: American Council for an Energy-Efficient Economy (ACEEE)).
- Semis have helped to improve the efficiency of cars by 40%, passenger planes by 121%, lighting by 339%, and computer systems by nearly 3,000,000% since 1978 (Source: Tech CEO Council).

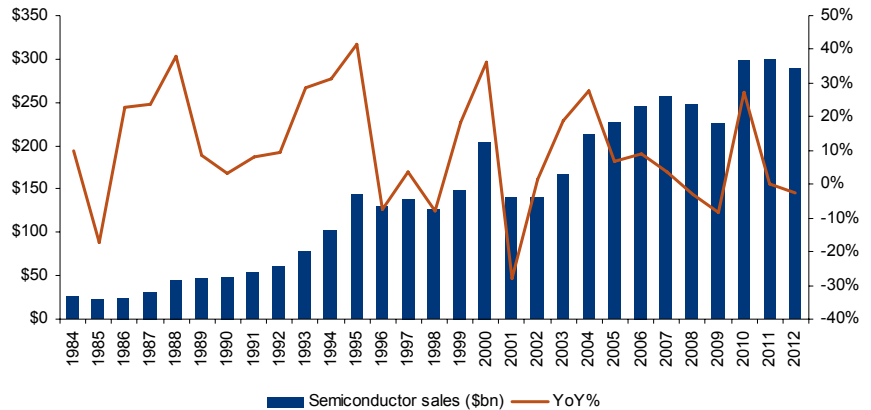
The energy savings from investing in semiconductor-enabled energy efficiency are about 2.7x the investment cost (Source: ACEEE)

Cross Reference - for further information on the semi market see our Global Semiconductor team's [Global Semiconductors, 04 February 2013](#)

Semi sales & growth forecast, upturn on the horizon

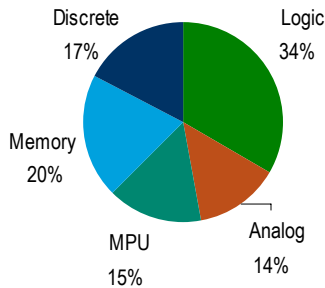
Our Global Semiconductors team anticipates that this c.US\$300bn sector, following two years of flat to down trends, will post robust 12.4% YoY growth for the semi IC market in 2013, well ahead of consensus at 5% YoY. We believe the combination of increasing demand from a gradual economic revival, improving confidence in distribution/retail to carry more inventory, pricing recovery in sectors such as memory, and secular tailwinds from product cycles will drive strong growth.

Chart 160: Semiconductor industry sales and YoY% change



Source: SIA, WSTS, BofA Merrill Lynch Global Research Estimates

Chart 161: 2011E semiconductor sales breakdown



Source: BofA Merrill Lynch Global Research

- Challenging market but gradual recovery is underway:** We were positive on the global semiconductor sector in 2H12 and see 2013 as favourable with accelerating growth, moderating capital spending, and attractive valuation/expectations. After a 3.1% decline for the global integrated circuit (IC) market in 2012, we raise our 2013 outlook from 11.1% to 12.4% YoY on a lower base, better ASP (mix, low capex, higher utilization), slightly better macro, and a global push for low-cost smartphones/tablets which are rich in semi content.
- Logic, memory, and discrete/opto strongest:** After a 2.5% decline in IC (ex memory) revenue in 2012, we expect a 9% rebound in 2013. However, we are cautious on microprocessor and analogue markets where we see growth of only 4% and 7%, respectively, after both declined by 6% in 2012. The logic IC market should grow 12% in 2013, from 1% growth in 2012, on our estimates. Memory sales declined only 5% in 2012 but we expect a rebound of 24% in 2013. Discrete/opto/sensor markets should also show revenue accelerating to 8%/11%/12%, respectively, in 2013E.
- But memory unit growth higher:** Memory unit growth has been faster than logic due to the digitalization of mass storage from magnetic storage to solid state storage built around flash memory, primary NAND. Computing and storage requirements continue to grow whether in large servers or small handheld devices due to the proliferation of content. While unit growth has been fairly steady, there will likely continue to be wider variations in revenue due to capacity cycles.

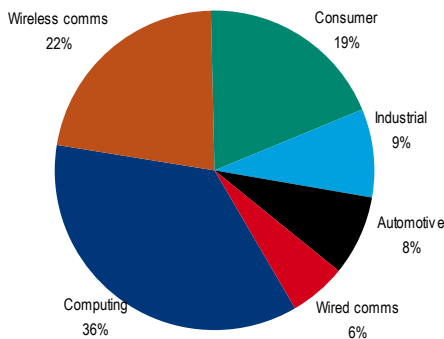
Semiconductor Year Ahead 2013, 07 January 2013

- **Industry growth vs. global GDP:** The semiconductor industry is highly cyclical with sales growth rates closely tied to global GDP trends. Over the past 15 years, semiconductor sales have grown at a median pace of 4.7% annually, slightly ahead of the 3.6% median GDP growth. Interestingly, whenever GDP growth has been more than 3.5%, it has had a ~3x multiplier impact on semiconductor sales (excluding hyper cyclical memory IC sales). On the flip side, whenever global GDP growth has been 3.0% or lower, semiconductor sales have typically declined.
- **Positives outweigh negatives:** We see the following 2013 positives: (1) 25% growth for mobile ICs, (2) a likely memory demand surge on China/EM smartphone upgrades, (3) a slightly improving macro picture, (4) moderating capex in 2H12, (5) Moore's Law intact at 28nm, driven by better design, and (6) attractively valued lower quality. Negatives appear to be (1) soft PC, consumer, and industrial markets, (2) a fully restocked supply chain, (3) muted macro/cyclicality, (4) TSMC/Samsung/Intel all chasing mobile-centric growth, (5) Moore's Law slowing at 20nm, and (6) quality stocks are richly valued.
- **Mobile-centric growth, consolidation elsewhere:** We expect mobile IC (ex memory) growth to accelerate from 13% in 2012 to 24% in 2013, driven by over 50% unit growth in smartphones/tablets, coupled with 3x higher content than featurephones. 2013 looks to be another challenging year for PC, consumer, and industrial suppliers as low growth is exacerbated by pricing pressures. However, low-cost smartphones create a virtuous cycle – driving demand for richer content/video which will drive more processor cores, faster connectivity (3G, LTE, WiFi), more memory, and bigger/better displays. In 2014, we forecast mobile IC growth to slow due to (1) high penetration rates, and (2) much slower content growth.

Semi-enabled energy efficiency opportunities

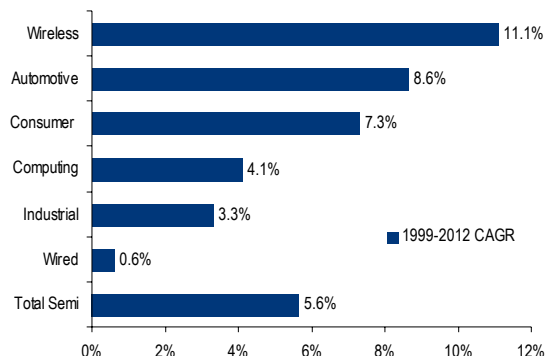
We anticipate that semis will be one of the biggest winners from energy efficiency. They are key to realising improved energy efficiency for the buildings, IT, power and transport sectors. Moreover, fundamentally for the sector, the value of semi components used in some of the solutions outlined below is set to increase by 5-60% – depending on the application – for each percentage point gained in efficiency (Source: Infineon).

Chart 162: Semi industry revenue share by end market



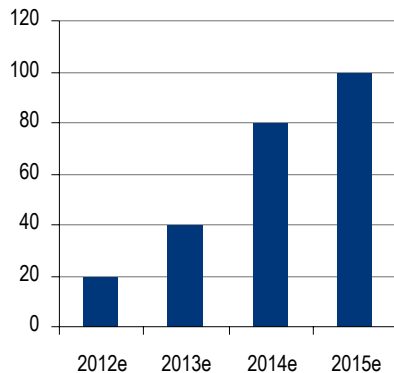
Source: iSuppli, BofA Merrill Lynch Global Research Estimates

Chart 163: Revenue CAGR by end market (1999-2012)



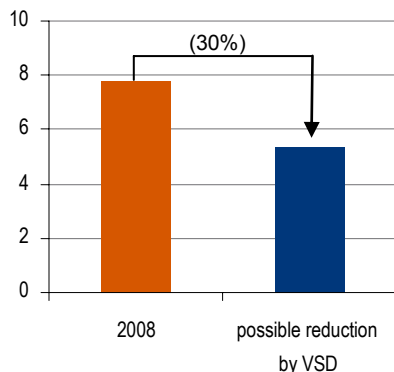
Source: iSuppli, BofA Merrill Lynch Global Research Estimates

Chart 164: Market penetration of highly efficient Platinum-label power supplies (%)



Source: Infineon, climate saver computers

Chart 165: Energy consumption of electric motors (in tn kWh)



Source: Infineon, IEA

a) Conversion efficiency

Electrical energy is converted many times between generation and reaching the end user with significant energy loss and cost implications. The efficiency at which AC is converted to DC power is key to overall power consumption and is being made more efficient by using power semi components that are capable of large-current, high-voltage electric power conversion:

- **HVDC** is an increasingly attractive transmission alternative for long distances – and the converter stations used in HVDC transmission systems depend on high-power semis. The value of semis is €2-10mn per station depending on capacity (Source: Infineon)
- **Home appliances:** an Energy Star “Platinum” labelled appliance has an energy conversion efficiency greater than 90%. Over the past three years, the use of high(er) efficiency Energy Star labels has cut EU electricity consumption by 11tWh – a saving of €1.8bn in terms of electricity costs (Source: European Commission).

b) Variable-speed drives, efficient power conversion

Electric motors such as drives, fans, pumps and compressors account for 40% of total global electricity consumption (Source: IEA). Most motors run at a fixed speed, which means billions of dollars in wasted energy. In China alone, by 2020 industrial motors will consume >30% of electricity and provide >10% of carbon emissions – likely 1-2% of global emissions (Source: ARM). Variable speed drives (VSD) can reduce energy use by up to 30% by matching driver speed or motor output to the actual energy requirements of an application (i.e. load-dependent speed control).

Semis are a key enabler, with VSDs typically containing €4 worth of power semis per kW of motor power – and power semi content ranges from €5000/MW or €10-100k, depending on application. Each US\$1 spent on purchasing a more efficient electrical motor can save US\$100 in energy costs over the motor’s lifetime (Source: Infineon). In addition to the cost benefits, VSDs are benefitting from increasing regulation of electric motors:

- The EU has stipulated since mid-2011 that electric motors in the 750-375kWh range must have electronic speed control, and more stringent regulations are set to follow in 2015 and 2017.
- Canada and the US have passed similar regulations.

Efficient motors could save the US 2% of total electricity consumption, the EU 7%, and China 2-10% (Source: ARM).

c) Buildings, smarter lighting & appliances

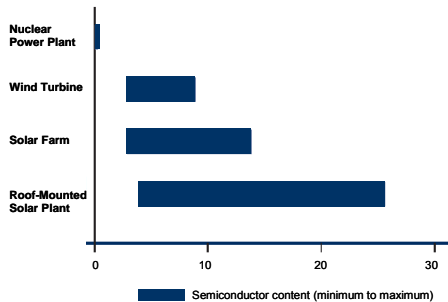
Chips are beginning to have an impact on residential energy usage. For instance in the US, residential energy usage in 2009 was c.22% of the total energy pie, but it represented over a third of total US electricity consumption. From 2008-18, the number of households in the US is projected to increase by 11%, while total electricity consumption is forecast to rise by only 6% (Source: Semiconductor Industry Association). These developments are in large part due to semi-enabled advances such as:

- **Energy-efficient lighting** such as controlling the ballasts for CFLs and LEDs (LEDs themselves are a semi technology), as well as lighting control.

These advances have seen a 21% decline in the energy used in lighting, one of the largest uses of residential electricity (Source: EIA Annual Energy Outlook 2009) and 40%+ in monthly lighting energy savings in developed market households (Source: ARM) (see further section on LEDs and Lighting).

- **Reducing energy for standby power for appliances** that are switched off, including the power drawn by external power supplies (e.g. transformers plugged into the wall to power appliances). Because standby power is drawing current 24 hours a day, and so many modern appliances consume standby power, it has been estimated that standby power is responsible for 5-10% of total residential electricity consumption (Source: IEA)
- **Enabling smart(er) buildings** with features such as microprocessor-controlled home appliances, garden/yard irrigation systems, heating and air conditioning, and motion-based lighting – which could be controlled via smartphones or tablets, for instance.

Chart 166: Semi content per GW of generated electric power (€mn/GW)



Source: Infineon

d) Renewables

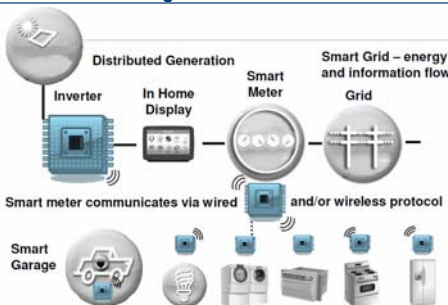
Alternative energy markets are generating growing volumes for advanced high-voltage power semis to convert energy to electrical power. The higher the efficiency of conversion, the more energy that can be used productively. Semi chips help to facilitate this conversion or make it more efficient, with advanced chips demonstrating conversion efficiency of as high as 20-40% for solar.

e) High semi content in solar & wind

There is substantially higher content of semis per megawatt of installed solar or wind capacity than for many conventional energy sources.

- A typical wind turbine can use up to €9,000 worth of semis per MW because of fluctuations in amplitude and frequency vs. €200 for coal or nuclear, where there are no such fluctuations and direct grid coupling is possible (Source: Infineon).
- Technological advances such as gearless and direct connect wind turbines also require more power semis than gear-based ones.
- Long-term R&D advances in areas such as nanomaterials, nanoscale devices and manufacturing should ultimately be leveraged by renewables manufacturers to reduce production costs.

Chart 167: Smart grid



Source: ARM

f) Smart grid, reducing distribution losses

Close to two-thirds of electrical power generated is lost in transmission and distribution – with inefficient grids' poor reliability costing US\$200bn/year in the US alone (Source: Electric Power Research Institute). In terms of opportunity, semis are a key enabler for the smart grid programmes being launched around the world – facilitating the creation of the "Electrinet" via power management, wireless, microcontrollers, digital signal, multimedia and embedded processors and sensors, as well as the need for high-end power management semi technology. Among some of the significant changes that semis are expected to achieve are:

- **Greater visibility into the grid as and when problems occur:** use of sensor and processor chips, together with optimized systems and software, to identify problems and determine solutions for utilities.

- **“Self-healing networks”**: use of advanced chip (e.g. systems-on-chip (SoCs combine sensing, communication, memory and processing capabilities) and system-level optimisation to create networks that can diagnose and correct their own problems.

The potential for cost savings by switching to the smart grid is estimated by various companies with involvement be more than US\$100bn/year, and the energy savings could be many hundreds of Gigawatts – along with massive chip-enabled gains in terms of generation, distribution and end-use consumption.

g) Sustainable transport

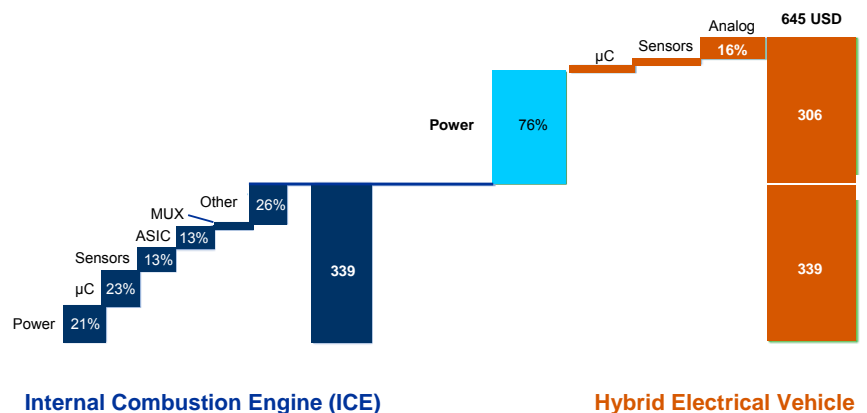
Chips are key to meeting government-mandated fuel efficiency and emissions requirements worldwide for the transport sector – aviation, rail and automobiles. Modern cars contain up to 100 chips – more than many high-end PCs – playing a role in anti-lock brakes, brushless fuel pumps, electric windows, GSP/SatNav, integrated starter and alternator, power steering (EPS), traction control and the electrification of drive train and sub-assemblies. Falling chip costs mean that the environmental and safety benefits are moving from premium to mass market cars – and sales revenues of automotive semis are expected to increase from US\$22.5bn in 2010 to US\$32.7bn by the end of 2015. (Source: GBI)

Electrification of the fleet

Power chips are set to play a much larger role in the auto sector’s move towards HEVs (i.e. recuperation *à la* trains) and EVs, as they enable the energy stored in the battery to power the electric motor that drives the vehicle. Increasing the penetration of EVs will be driven by improved relative economics and technical advances, which increase the battery range – but they could see penetration as high as 7-25% by 2020 according to industry estimates (Source: JD Power, Nissan/Renault and Ford - cf. [Renewable Energy, 14 December 2011](#)). The semi content per car is generally US\$250-300 in ICE vehicles but rises to US\$600-700 for hybrids & EVs (Source: Infineon) – mostly power semis as battery-powered vehicles need the most efficient power transistors to achieve a decent range.

Chips are at the heart of enabling telecommuting via advanced ICT facilities. In the US, telecommuting saves the equivalent of 9-14bn kWh of electricity/year and reduced CO2 emissions by 14Mt/year (Source: Consumer Electronics Association)

Chart 168: Three quarters of incremental semi content in hybrids by 2015 will be power



Source: Strategy Analytics

Low power servers new battle b/w ARM and Intel

Electrical usage is ~40% of the total cost of ownership in a data centre, and there is a growing trend towards low-power microservers. Intel dominates (95% share) the server processor market but most products are geared towards high

Cross Reference
US Semiconductors, 07 February 2013

performance applications. There are several alternatives that are using ARM and alternative architectures (Calxeda, Applied Micro, Cavium and Tilera), which are in various stages of shipping 32-bit/64-bit products, with very low power consumption. While this emerging competition is interesting, our US Semis team sees minimal threat to Intel for at least the next two years due to its software compatibility, incumbency, wide product breadth, manufacturing lead, and the inherent capabilities (64-bit, virtualization, ECC) of x86 architecture. Also, Intel's forthcoming 22nm Tri-gate Atom-based Avoton product could bring low, tablet-like power levels into the server environment. Various industry estimates (IHS, Linley) peg the microserver segment at ~10% of the server market.

Table 81: BofAML Lighting & LED Energy Efficiency Stock List

Company	EE exposure
CREE INC	High
EPISTAR	High
EVERLIGHT	High
SEMILEDS CORP	High
SEOUL SEMICONDUCTOR	High
VEECO INSTRUMENTS	High
PHILIPS ELECTRONICS	Medium
SIEMENS	Medium
GENERAL ELECTRIC	Low

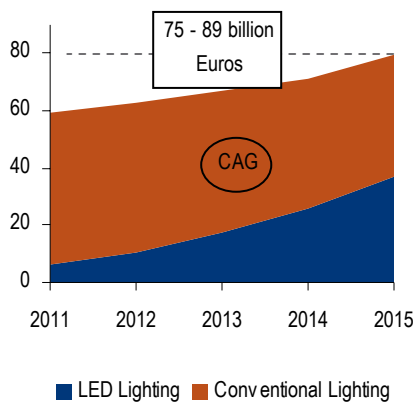
Source: BofA Merrill Lynch Global Research. * EE exposure = BofAML estimates of current sales derived from energy efficiency products, services, technologies and solutions

Lighting & LEDs

Lighting consumes 19% of the world's electricity output and is extremely wasteful with up to 30% to 75% of lighting systems considered inefficient (source: IEA). Without efficiency breakthroughs, it is estimated that electricity consumption by lighting will increase by 60% in the next 20 years (source: UNEP). New technologies can reduce electricity consumption by up to two-thirds. Moreover, energy efficiency lighting sources such as CFLs, LEDs, luminaries, control gear and intelligent lighting control tools and concepts can thus make significant contributions to reducing electricity use and cutting CO2 emissions.

We anticipate strong growth for energy efficient lighting solutions, helping the global lighting market to grow at 5-7% CAGR to become a €75-89bn market by 2015 (source: Philips). While a lacklustre macro economy has impacted the general lighting market in the near term, LEDs in lighting are finally emerging as the biggest growth opportunity in the medium to long term. Short-term LED usage will be driven by mobile phones, TVs and PCS, with 60-70% of new TVs having LED backlighting. While oversupply and low utilisation remain issues, albeit easing, we see the industry pulling into a healthier supply/demand balance past 2014. A speedier drop in LED lighting prices – including the 2013 magic price point breakthrough of Cree's sub-US\$10 LED bulb for Home Depot – could be a major breakthrough for residential solutions. Spurred on by regulation, LEDs could represent 45% of the global lighting market by 2015 (source: Phillips) and residential LEDs could represent 70% of the general light market by 2020 (source: McKinsey).

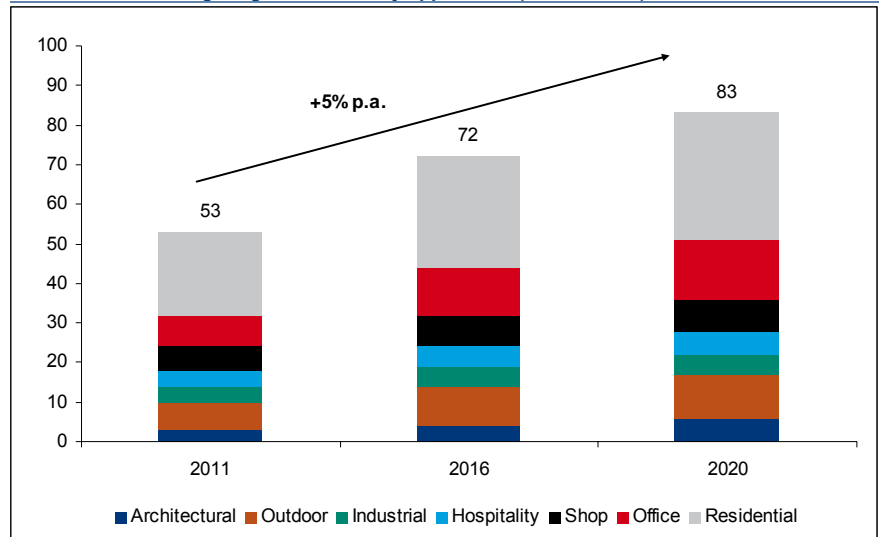
Chart 169: Global lighting market (EUR billions)



Source: Phillips

We believe that a number of companies are well placed to benefit from the theme of energy efficiency in LEDs and lighting through their involvement in areas such as chips, CFLs, CCFLs, components, deposition equipment, LEDs, lighting management, lighting solutions, luminaries, MOCVD equipment, process equipment, and sapphire ingot/wafer manufacturers among others.

Chart 170: General lighting market size by application (EUR billions)

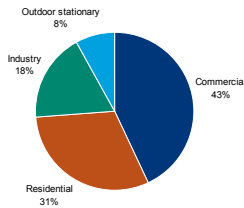


Source: McKinsey

Lighting, 19% of electricity use worldwide

Lighting consumes 19% of global electricity usage or over 2,650 TWh. Of this amount, approximately a third is for residential lighting and two-thirds for commercial buildings, industry and exterior lighting (source: IEA). The figures are even higher for developed markets such as the US, where lighting accounts for 22% of electricity consumption (source: US EPA).

Chart 171: Lighting electricity consumption by sector



Source: IEA, BofA Merrill Lynch Global Research

Up to two-thirds of lighting is inefficient & outdated

Up to two-thirds of the current global lighting installed base is considered to be inefficient, as:

- 75% of offices and industrials use outdated, inefficient lighting systems
- 67% of the installed residential lighting base uses incandescent lamps
- 30% of road light use technology dates back to the 1960s (source: IEA).

Lighting accounts for 6-8% of global CO2 emissions

Globally, lighting is responsible for more than 1,900 Mt of CO₂, or 6-8% of CO₂ global emissions. Grid-based lighting is responsible for 81% of these emissions with fuel-based lighting (e.g. kerosene) and vehicle lighting accounting for the remainder (source: IEA).

Electricity consumption to grow 60% in next 20Y

Without efficiency breakthroughs, it is estimated that electricity consumption by lighting will increase by 60% in the next 20 years (source: UNEP).

Dramatic energy & cost savings are possible via efficiency

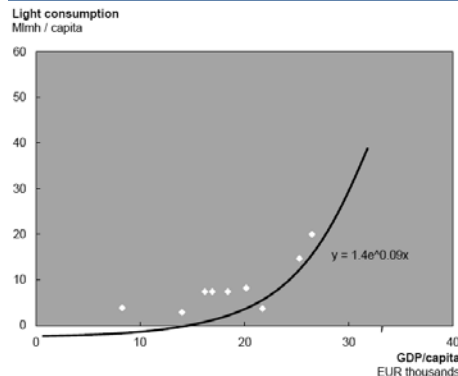
The potential for energy efficiency gains is significant – particularly at the use phase, which is responsible for 90% of the energy consumed by a light source. Broadly speaking, 40% of future global energy demand for lighting could be avoided by switching to efficient light bulbs such as compact fluorescent (CFLs) or light-emitting diodes (LEDs) (source: UNEP). A global move towards more efficient lighting technologies could result in:

- Energy savings of 406 TWh or 2% of global electricity consumption
- Direct financial savings of US\$47bn
- 246Mt in reduced CO₂ emissions or c.1% of global emissions (source: IEA).

US adoption of LEDs, US\$250bn in energy savings (2030E)

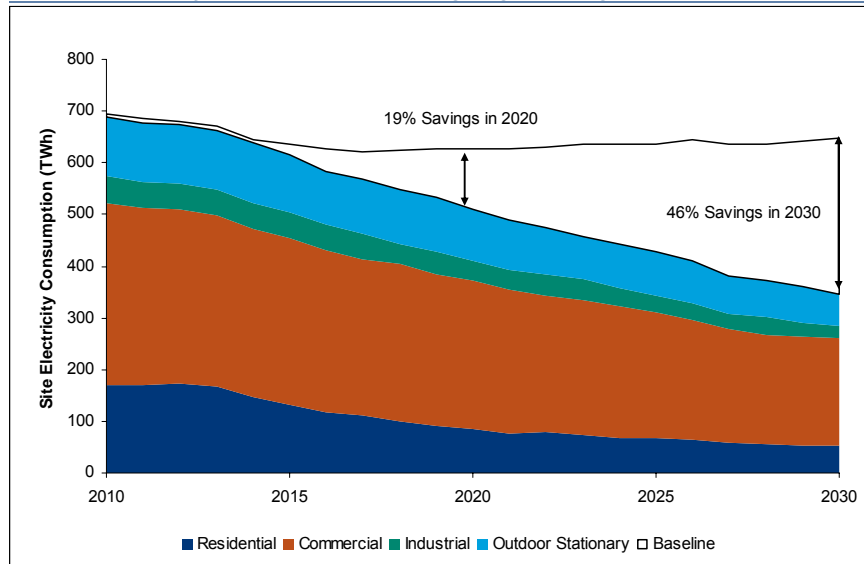
Increasing LED adoption could lead to annual energy savings in the US alone of 300TWh by 2030E, equivalent to nearly US\$30bn of energy savings and 210m metric tons of CO₂ (source: US DoE). From 2010 to 2030, the cumulative energy savings from LED adoption could be nearly 2,700TWh, representing US\$250bn at today's energy price and 1,800m metric tons of CO₂ (source: US DoE).

Chart 172: Lighting consumption vs. GDP (per capita)



Source: Vattenfall

Chart 173: Electricity consumption of various lighting technologies



Source: US DOE, BofA Merrill Lynch Global Research

Widespread global adoption of LEDs could be a game changer

Assuming we saw widespread global adoption of LEDs – the savings could be even greater. Globally, an LED-enabled 40% efficiency improvement could result in over US\$150bn in reduced electricity costs (40% savings x US\$0.15/KWh) and a 555Mt cut of emissions (source: Philips).

Table 82: Global energy & CO2 savings from converting to LEDs

Savings potential	EU	NAm	LatAm*	Asia-Pac	MEA	Global
Outdoor lighting						
€bn	2	3	1	3	1	10
MtCO2	8	15	3	18	8	52
Office						
€bn	5	5	2	7	3	22
MtCO2	16	28	6	43	21	114
Retail						
€bn	3	5	2	4	1	16
MtCO2	10	29	6	27	8	79
Home						
€bn	9	15	1	10	5	40
MtCO2	32	81	3	65	33	214
Hospitality						
€bn	2	2	0	2	1	7
MtCO2	6	7	1	15	7	36
Healthcare						
€bn	2	1	0	2	1	5
MtCO2	7	5	0	10	5	27
TOTAL						
€bn	28	40	9	36	15	128
MtCO2	98	210	24	236	102	670

Source: Philips * includes Mexico

Top 10 countries benefitting from moving to more energy efficient lighting

Electricity consumption savings		%
1.	Cambodia	31
2.	Madagascar	25
3.	Laos	21
4.	Nepal	20.8
5.	Burundi	20
6.	Nigeria	15
7.	Algeria	14
8.	Benin	11.6
9.	Yemen	11.3
10.	Senegal	11

Source:

Social impacts, the poorest will benefit most

Emerging market citizens will be the biggest beneficiaries of the energy savings, and cost and CO2 reductions gained by moving to efficient lighting technologies.

There will also be significant benefits for the estimated 1.6 billion people worldwide who do not have access to grid-based technology, who use over 77 billion litres of environmentally “unfriendly” and unsafe/unhealthy kerosene for lighting every year, emitting 190Mt of CO2 (source: UNEP). This would, in turn, have positive impacts on productivity, job creation, education, and in reducing GDP losses caused by poor infrastructure.

Table 83: Benefits of a Transition to Energy Efficient Lighting

Country	Cost Reduction		Electricity consumption Reduction	CO2 Emissions Reduction		
	Annual Saving (million USD)	Payback Period (month)	Large power plant* electricity output equivalent	Reduction (Mt CO2)	Mid-size cars off the road (million)	Hg Reduction (kg)
EU	35,713	4	48	61.5	15.37	5,284
USA	23,562	7	60	111.8	27.94	11,284
China	21,618	3	50	133.8	33.46	16,318
Japan	6,102	2	8	13.1	3.27	942
Brazil	3,776	4	7	1.7	0.43	72
Russia	2,850	8	14	16.9	4.23	980
Canada	2,250	9	7	4.3	1.07	445
India	2,075	9	11	39.9	9.97	3,138
Ukraine	1,529	16	5	7.4	1.85	739
Australia	1,379	4	3	10.4	2.61	1,088
Turkey	1,328	2	2	4	1	255
Rep. Korea	1,054	4	4	7	1.75	748
Mexico	990	5	3	5.1	1.28	159
Philippines	746	3	1	1.7	0.42	103
Thailand	671	4	2	3.4	0.85	148
Chile	597	3	1	1.2	0.3	77
Malaysia	555	4	2	3.8	0.96	200
Indonesia	536	10	2	7.2	1.79	430
Israel	435	2	1	1.5	0.38	159
S. Africa	415	9	2	8.2	2.05	894

Source: UNEP, BofA Merrill Lynch Global Research

Legislation is going one-way

Legislation is driving a shift towards more energy efficient lighting solutions as incandescent light bulbs – which are cheap and represent 50-70% of worldwide bulb purchases and are relatively inefficient. Up to 95% of the energy emitted by incandescents is heat, and their efficiency is inherently low, their lifespan far shorter, and reliability much poorer than the new generation of bulbs. As a result, many nations have banned or are moving to ban the sale of incandescent bulbs. While the banning of incandescent lamps will not immediately benefit LED bulbs, we believe it will increase consumer awareness of LEDs.

18 April 2013

Chart 174: Global phase-out of incandescent bulbs

	2009	2010	2011	2012	2013	2014	2015	2016
Europe								
European Union	100W	75W	60W	40W-15W		Halogen available		Efficiency Level B
Switzerland	100W	75W	60W	40W-15W		Halogen available		Efficiency Level B
Turkey				Aligned with EU		Halogen available		Efficiency Level B
North America								
British Columbia		75W, 100W			40W, 60W		Halogen available	
California		100W		75W	40W, 60W		Halogen available	
USA (except CA)				100W	75W		40W, 60W	Halogen available
Canada (except BC)						75W, 100W	40W, 60W	Halogen available
Latin America								
Cuba	Banned all incandescent filament lamps including halogen in 2006							
Argentina	Banned all incandescent lamps $\geq 25W$ but not including halogen							
Columbia		$\geq 150W$		$\geq 75W$		$\geq 60W$	Halogen available	
Mexico				100W	75W	40W, 60W	Halogen available	
Brazil				$\geq 100W$	$\geq 60W$	$\geq 40W$	$\geq 25W$	Halogen available
Asia								
Malaysia		$\geq 100W$	all other wattages		Ban on all Filament Lamps in favor of CFLs and LEDs			
Russia		$\geq 100W$	Halogen available					
Israel		$\geq 60W$	Halogen available					
ROK			150W-70W			70W-25W		
Taiwan			Min. requirements for consumer lamps: 22 lm/W for $\geq 100W$, 20/W for $\geq 60W$, 18m/W for $\geq 40W$, 151m/W for $\geq 25W$					
China			$\geq 100W$			$\geq 60W$		$\geq 15W$
Japan	Gradual voluntary transition by major lamp companies to high efficacy lighting - no mandatory regulatory regulations in place							
Philippines	No Government mandated ban at this time. Bill to require a minimum of 15lm/W efficacy introduced in the Philippines Senate							
India	Some voluntary programs, but no mandatory standards for lamps rated at 100W or below							
Oceania								
Australia	Traditional incandescent phased out in 2000, halogen available							
New Zealand	Intention was to phase out traditional incandescent lamps the same way as Australia, but government elected in 2008 did not proceed							

Prepared by Pekka Hakkarainen Dec 2011

Phase out event or period
Higher efficacy filament lamps allowed
No filament lamps allowed

Source: Global Lighting association – NEMA update

Lighting accounts for c.12% of China's electricity use and the incandescent phase-out could save it 48bn kWh of power pa (source: NDDRC)

- EU is the long-standing leader:** An initial Europe-wide ban applied to general-purpose, non-directional incandescents began in 2009, with all clear bulbs over 100W having to be made of more efficient types. This limit has been moved down to lower wattages, and the efficiency levels raised at the end of last year. The EU banned the manufacture and import of all incandescent bulbs from 1 September 2012 and has also given the target of 2016 to phase out halogens. The UK government said the ban would result in an average annual energy savings of £108mn for the UK between 2010 and 2020.
- China's 5Y phase-out:** In November 2011, China – the world's largest producer of energy saving and incandescent bulbs – announced a five-year phase-out of incandescent light bulbs with a ban on 100W+ bulbs from 1 October 2012, a ban on 60W+ bulbs from 1 October 2014, and a ban on 15W+ bulbs from 1 October 2016. Beijing plans to evaluate roll-out for one year beginning September 2015 and may adjust the last phase depending on results. Our checks suggest that Chinese subsidy is only likely to be a smaller-scale regional programme, rather than a nation-wide programme as anticipated by the market.
- U.S. Energy Independence & Security Act:** this requires all general-purpose light bulbs (310-2600 lumens) to be 30% more energy efficient than current incandescent bulbs by 2012 to 2014. 100W incandescents are no longer manufactured for sale (as from 1 January 2012), by 2013 the rule hits 75W bulbs, and by 2014 40W bulbs. By 2020, a second tier of restrictions could require all general-purpose bulbs to produce at least 45lumens/watt similar to current CFLs (ie, 200% greater efficiency) – although it is currently being challenged.

Table 84: Timetable of Chinese govt banning incandescent lamps

Period	Target
From 1 Oct. 2011 to 30 Sept. 2012:	Release the plan
From 1 Oct, 2012:	Impose sales and import ban on 100W+ (including 100W) general lighting incandescent bulbs
From 1 Oct, 2014:	Impose sales and import ban on 60W+ (including 60W) general lighting incandescent bulbs
From 1 Oct, 2015 to 30 Sep. 2016:	Assess and review the plan
From 1 Oct, 2016:	Impose sales and import ban on 15W+ (including 15W) general lighting incandescent bulbs

Source: BofA Merrill Lynch Global Research

Table 85: Timetable of global government bans on incandescent lamps

Country	Legislation	Available Subsidies	Ban Target Date	GDP Rank
US	Yes	Yes	<2020	1
EU	Yes	Yes	<2012	2
Japan	Yes	Yes	2012	3
China	Yes	Yes	2017	4
Canada	Yes	Yes	2012	5
Russia	Yes	Yes	<2014	7
Australia	Yes	No	2010	8
Korea	Yes	Yes	2013	10
Taiwan	Yes	Expired	2012	16

Source: Sterne Agee 2010; World Bank 2009; OECD 2010; LEDinside; BofA Merrill Lynch Global Research

Environmental challenges have not yet been tackled

We note that from an environmental perspective, some of the legislation fails to address problems associated with issues such as the disposal of energy-saving bulbs. For instance, CFLs contain small amounts of mercury (c.4.0mg per bulb). A broken bulb will release about 4% of its mercury content, causing some stakeholders to raise potential human health and safety concerns that have not yet been addressed by most of the legislation. No mercury is used in LEDs.

Table 86: Lighting policy/subsidy summary

	Subsidy/policies	Period	Details	Subsidy (if any)
Japan	Basic Energy Plan	By 2020	Replacing 100% of lights with high-efficiency lights (including LED and organic EL lighting) on a flow basis by 2020 and on a stock basis by 2030.	
	Tax reduction for SMEs and depreciation allowance are granted to support the initiative. Eco-point program	2009 - 2011	The Japanese government began to implement an energy-saving appliance subsidy called the Eco-point program in May 2009. Consumers can earn eco-points from purchase of energy-efficient appliances. In December 2009, the government added LED lamps to the list of redeemable products. From April 2010, consumers were allowed to exchange their eco-points for LED lamps at twice their value.	
South Korea	For example, 2,000 eco-points were needed to redeem an LED lamp priced at ¥4,000 (around \$50). 20/60 plan (succession of the 15/30 plan)	By 2020	South Korea's Knowledge Economy Ministry announced in 2006 a "15/30" plan, intending to achieve 30% LED lighting commercialization by 2015. The ministry later announced a "20/60" plan aiming to achieve 60% commercialization by 2020 and a full ban on producing and selling incandescent lamps by 2014.	
China	2012/13 subsidy on LED lighting products	2012-2013	39 companies with 183 LED lighting products won the 2012/13 LED lighting subsidy from Chinese government. Total subsidized volume amounts to 8.73mn (7.85mn/880,000 indoor/outdoor).	Four types of LED lighting products, ie, indoor downlight, reflective self-ballasted lamp, street lamp, tunnel lamp
	Local subsidies for MOCVD purchase	2009 - 2011	Yangzhou government started first to subsidize MOCVD purchase. Other local governments followed suit to encourage the development of LED industry. Yangzhou's subsidy expired in July 2011. Others are reportedly stalled.	It varies with each local government. Yangzhou government gave out RMB10mn per set of MOCVD equipment. The total subsidy is estimated to be US\$ 1.6bn.
	Roadmap of 10 cities and 10 thousand lights Phase I: Streets, highway, subway, wharf, square, park, and other lighting 2) Local government: at least RMB60/ton; 3) Dependent on local government	By the end of 2009	1mn by the end of 2009	
	Phase II: Streets, highway, subway, wharf, square, park, and other lighting; * 2/1.3mn is accumulated installation volume	2010~2012	2mn by 2012; 1.3mn lamps by 2010	
	Subsidy is evaluated based on how much energy (tons of standard coal) is saved Phase III: Likely 4mn incremental LED lamps. Industry scale will reach RMB500bn. Export will reach US\$30bn.	By 2015		To be confirmed

Table 86: Lighting policy/subsidy summary

	Subsidy/policies	Period	Details	Subsidy (if any)
EU	Funding by European Union on solid-state lighting technology	On-going	A number of projects are currently underway including SSL4EU, SMASH, SINOPE, RAINBOW, ECOSTREETLIGHT and THERMOGRIND.	These projects have a combined project cost of approximately \$43mn with project funding of \$31mn from the EU. The two largest programs are funded by OSRAM.
	Competitiveness and Innovation Framework Programme	2012 onwards	This program funds large-scale innovative lighting systems based on SSL. Projects include exterior lighting (streets, restaurant areas and public buildings) as well as interior lighting (museums and other visitor centres), and are expected to start early in 2012.	It is anticipated that two to three projects will be supported with a total EU funding of up to \$13mn (50% cost share).
US	Investment on Solid-State Lighting R&D	On-going	Department of Energy is investing in R&D for solid-state lighting (SSL) including LED and OLED over the years with targets to improve manufacturing throughput, reduce OEM lamp price, downtime and assembly cost	
	Tax credits, rebates and energy loans	On-going	States offer tax credits, energy loans and rebate programs.	Tax credits for both residential/commercial applications and utility rebates vary by state.

Source: various governments, METI, DOE, DSIRE, Digtimes

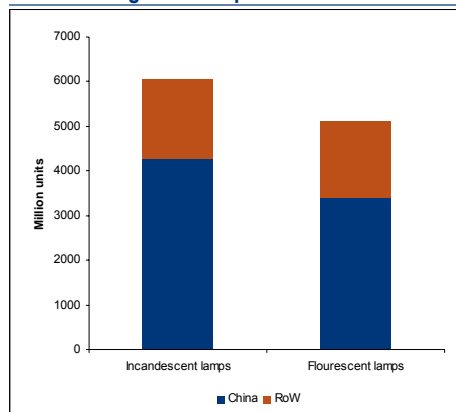
CFLs have captured nearly 25% of the light sockets in US households today, a number sure to grow as energy efficiency regulations take effect (source: GE Lighting)

CFLs, the here and now solution

Compact fluorescent lamps (CFLs) are the first and most widely adopted alternative to incandescents and can save about 80% power compared with an incandescent bulb. Compact cold fluorescent (CCFL) lighting remains the low-cost energy efficiency solution over any different periods of ownership considered. Moreover, a CCFL bulb currently costs around a twentieth of the price of a comparable LED device.

The CFL industry is characterized by rapid demand growth due to rising public awareness, low entry barriers, rising capacity, and heated competition. China currently accounts for close to 70% of CFL global production. However, Chinese brand recognition of Chinese products in overseas markets is poor, with about 50% of its output directed to OEM orders from foreign companies.

Chart 175: Light source production in China

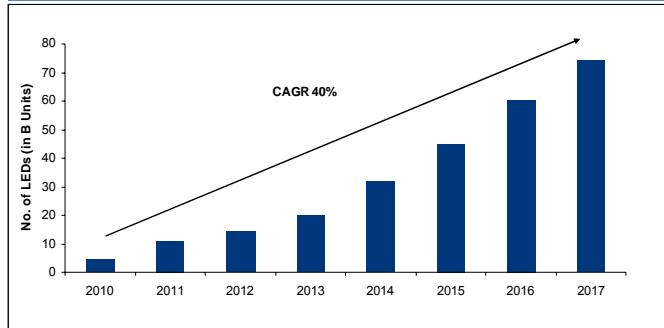


Source: Ministry of Industry and Information Technology, China

LEDs, the long-term solution

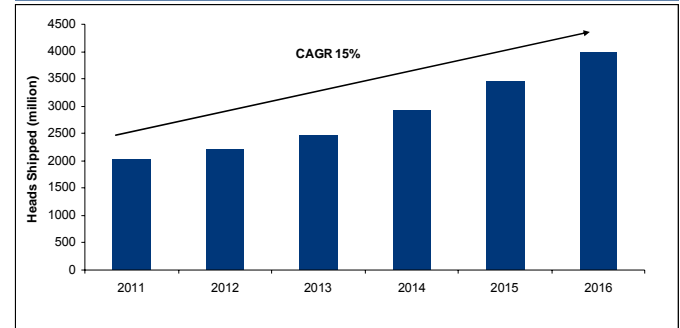
Light Emitting Diodes (LEDs) are electronic semiconductor components that emit light when a current flows through it. The efficiency of LEDs continues to improve and some chips are able to emit more than 100 lumens/watt. When used properly, LEDs can achieve a service life of 50,000 hours or more – which would mean a 17 year life-span when used 8 hours a day. LEDs thus need to be viewed as a long-term energy efficiency investment.

Chart 176: LED lighting chip demand



Source: Veeco

Chart 177: Thin film head forecast



Source: Veeco

Instead of materials that turn “incandescent” when heated, solid-state products rely on “electro luminescence” from light-emitting diodes (LEDs). When electricity is applied to an LED, light is emitted from the interface between two semiconducting materials. The LED is typically put into a ceramic/ plastic housing and sold as a finished package that can be connected to an electrical circuit (source: GE)

Significant advantages to traditional lighting

LEDs can be used for both general and special purpose lighting and have unique advantages to all previous light sources including:

4. low energy consumption and heat emission;
5. long service life of up to 50,000 hours;
6. availability in any colour;
7. turn on instantly and are unaffected by cycling on and off;
8. compact size opens up new design opportunities;
9. no toxic materials such as mercury and no infra-red/ultra-violet radiation;
10. less apt to break and not sensitive to vibration; and
11. low disposal and transport costs.

Table 87: LED bulb spend comparison (based on 6h/day use or 21,900 hours over 10Y)

	Incandescent	Halogen	CFL	LEDa	LEDb	LEDc
Purchase price	\$0.41	\$4	\$4	\$10	\$16	\$30
Electricity usage	60 W	42 W	13 W	13.5 W	12.5 W	10 W
Lumens	860	570	825	850	805	940
Lumens/Watt	14.3	13.6	63.5	63	64.4	94
Color Temperature Kelvin	2700	3000	2700	3000	2700	2700
CRI	100	100	82	>75[28]	85	92
Lifespan (hours)	2000	3500	8000	25000	25000	30000
Bulb lifetime in years @ 6 hours/day	1	1.6	3.7	>11.4	>11.4	>13.7
Energy cost - 10Y @ 15 cents/kWh	\$197	\$138	\$43	\$44	\$41	\$33
Total 21,900 hour spend	\$201	\$166	\$55	\$54	\$57	\$63

Source: BofA Merrill Lynch Global research

Significant hurdles to implementation

The LED market is currently characterised by very rapid growth and extremely short product life cycles. The short life cycles mean increased capex on R&D, production and marketing. Luminaries become uncompetitive after a relatively short time and have to be replaced by successor products. This speeds up activity in the lighting sector and ties up large amounts of capital and resources. Because costs are relatively high and volumes still comparatively low, LED light sources and luminaries are fairly expensive. LED adoption for luminaries varies strongly depending on the application:

- **Dominant in art, entertainment and retail display lighting, and retailer/hospitality** driven by effects not available in traditional lights
- **High LED penetration in street lighting** due to low total cost of ownership (TCO)
- **Limited adoption in office building and residential**, given principal-agent problem for office building and low TCO awareness in residential segment
- **Lack of consumer awareness** of new efficiency regulations with up to two-thirds unaware (source: GE Lighting) as well as to installation and usage.

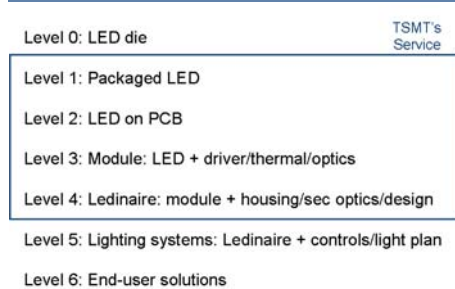
Costly but long-term payback will improve

High production costs and the price of LEDs are expected to drop in the medium term, thus making LED products even more attractive. Based on BofAML estimates, at an electricity price of US\$0.15/Kwh, LED lighting will cost less than incandescent lighting after about 16 years of usage. For LED to be widely used, the cost needs to fall significantly or the government has to legislate for its usage. Both are likely. The LED lamp we compare below is one of the first commercial 60W equivalent devices and we would expect prices of these to fall rapidly as production expands and technology matures. Please note that the comparison here excludes the cost of associated fixtures and fittings. LEDs can be implemented in a highly integrated manner, with minimal maintenance costs. This may prove an additional attraction to consumers.

Cree’s sub-\$10 bulb breakthrough

In March 2013, Cree launched 40W/60W warm white LED light bulbs at US\$9.97/12.97 at Home Depot. The price points are at the lower end of our LED bulb survey, US\$11.7 for 40W and US\$14.6 for 60W, and many LED makers are positive it can help speed up the LED adoption rate in the residential market, which is now at a low-single digits %. These bulbs will save 84% of the energy compared with traditional incandescents (source: Cree). Additionally, these bulbs are dimmable with a rated life of 25k hours and a colour rendering index of 80.

Chart 178: LED lighting value chain

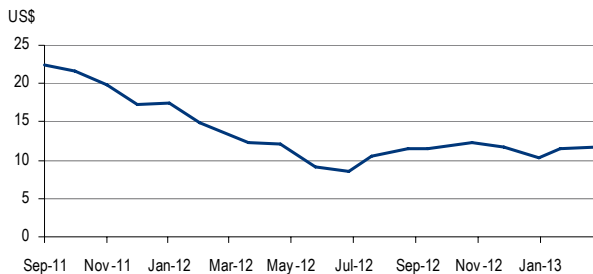


Source: Company data, BofA Merrill Lynch Global Research

Cross Reference

[LED Monthly, 08 March 2013](#)

Chart 179: Retail price of 40W replacement LED bulb in the US



Source: BofA Merrill Lynch Global Research

Chart 180: Retail price of 60W replacement LED bulb in the US



Source: BofA Merrill Lynch Global Research ; non-brand 60W LED bulb

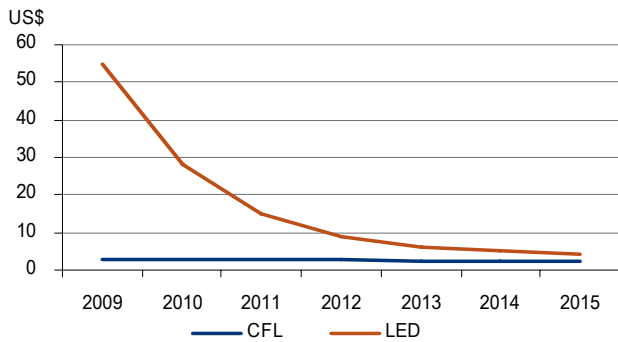
Cross Reference

[LED Monthly, 08 March 2013](#)

China outlines LED game policy

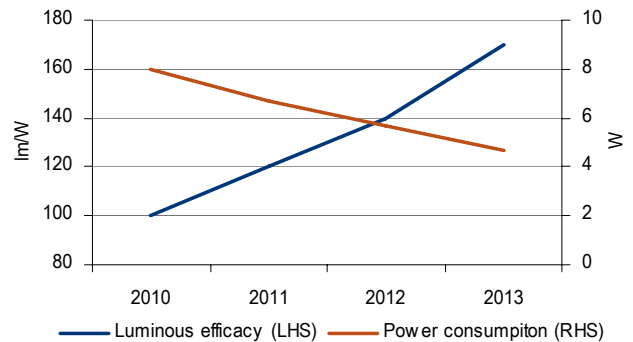
China's NDRC and five other ministries announced a strategic plan for the Chinese LED lighting industry in mid-Feb. It aims to achieve 30% YoY revenue growth in 2015 and reach RMB450bn, of which LED lighting products will account for RMB180bn. Domestic makers should supply 80% of the LED chips and 70% of the MOCVD machines, key raw materials and testing equipment. NDRC also plans to develop 10 to 15 leading LED makers nationwide, down from 20 to 30 announced previously, signalling the government's support for further industry consolidation.

Chart 181: Retail price – LED vs. CFL



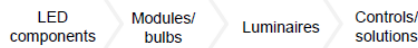
Source: BofA Merrill Lynch Global Research

Chart 182: Luminous efficacy vs. power consumption (800 lm output)



Source: BofA Merrill Lynch Global Research

Chart 183: Digital lighting value chain



Source: Philips

Adoption of LED lighting is key to long-term growth

We believe that the pace of the adoption of LED lighting holds the key to the LED industry's long-term growth outlook once LED-TV demand is saturated. Factors currently holding back the widespread adoption of LED lighting include light quality and the high initial purchase cost for consumers. Currently, CFL is a mature technology and much cheaper than LED, so we think is likely to remain the dominant energy saving lighting solution in the foreseeable future. But LED's attractive features such as durability, reliability and high energy efficiency we think give it a chance to expand its market share once technology improves and costs come down.

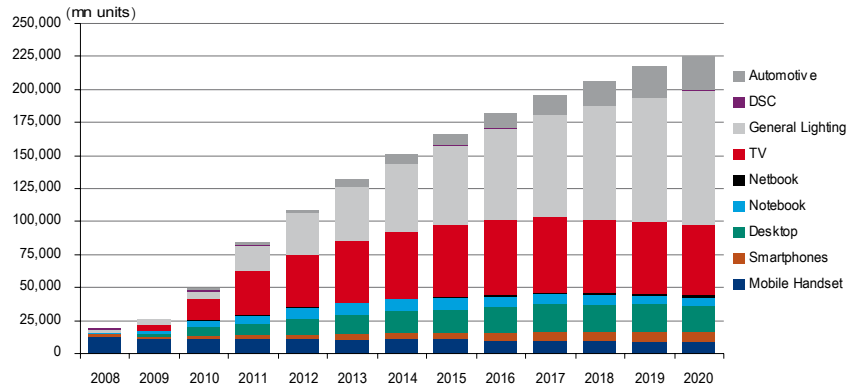
OLEDs

Organic Light Emitting Diodes (OLEDs) use different materials to LEDs: they use organic materials, which give a lower current density and lower luminance. In addition, OLEDs emit light over a large area. Long-term they could pose a competitive threat to LEDs, but LEDs currently have a strong price advantage.

Near-term LED outlook

LEDs are used in many applications including mobile devices, automotives, mid-to-large-sized LCD displays (notebook, PC monitor and TV etc.), and general lighting. At the moment, mobile phone and displays account for some 60% of total LED consumption. We expect the TV market to be the main driver of LED usage over the next few years, followed by the general lighting market.

Chart 1.10: LED demand growth comes from TV (short term) and general lighting (long term) (OLD)



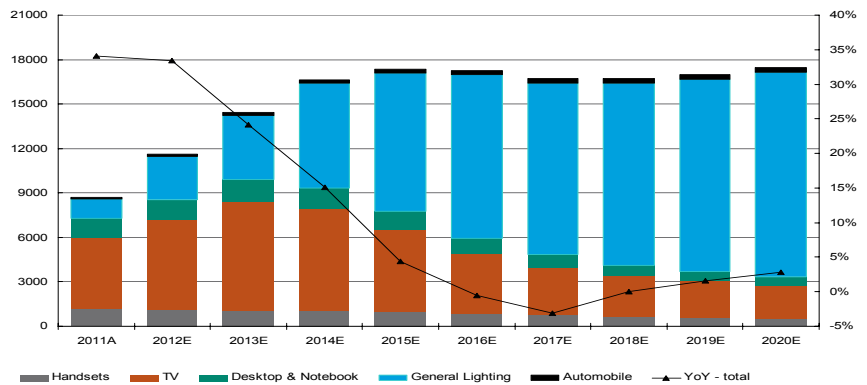
Source: BofA Merrill Lynch Global Research estimates

[Cross Reference](#)
[CREE, 02 July 2012](#)

LEDs for illumination market

We estimate that the market for LEDs used for illumination, also known as the white LED market, should amount to approximately US\$11.6bn in 2012. The LED market has grown rapidly during the past two years as unit volumes have expanded, driven most notably by sales into the television market and early penetration of the general lighting market. Although we expect continued volume growth, device revenue growth could flatten by 2015 as prices continue to fall and display backlighting markets approach saturation. General lighting is likely to become the most important driver of the overall market by 2014 or 2015.

Chart 184: White LED revenue breakdown by application and segment YoY %



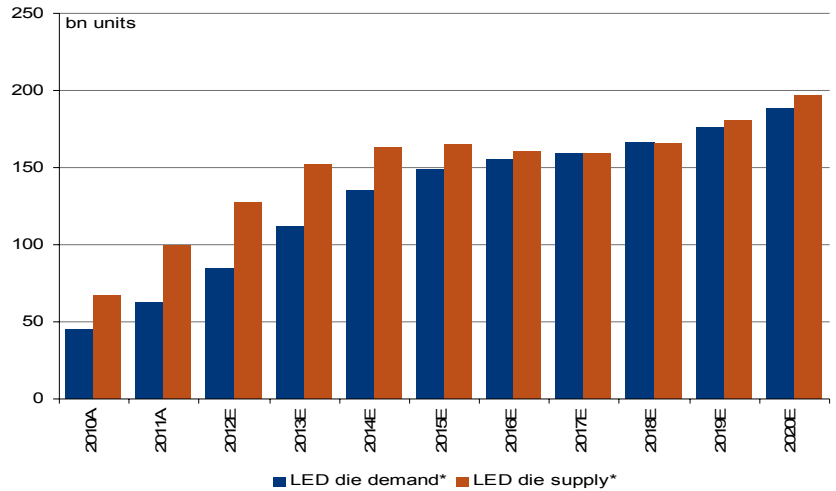
Source: BofA Merrill Lynch Global Research estimates, Company reports

[Cross Reference](#)
[CREE, 02 July 2012](#)

LED tools demand and supply

Our unit-based supply and demand model suggests that the industry could be in oversupply for the next several years, especially as tool shipments reaccelerate. We see a healthier supply/demand balance after 2014, but we admit that this is predicated on a slowdown in tool shipments that is very difficult to predict. It seems likely that another sharp reversal in tool shipments is on the way for 2014-15 unless a large additional source of demand emerges.

Chart 185: LED Device Supply and Demand

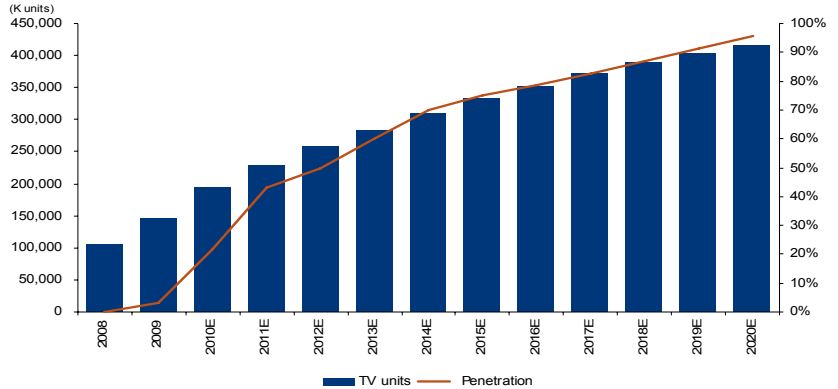


Source: BofA Merrill Lynch Global Research
* Measured in equivalent die units, using industry average die size per Chart 11

LED TV BLU (backlit unit): the fastest growing area

Traditionally, mobile phones accounted for the largest portion of the LED market (63% in 2008). In 2009, major TV makers started to actively launch LED-based TVs, boosting LED demand.

Chart 1.11: LED penetration in TV - ratio of LED to total LCD TV shipment



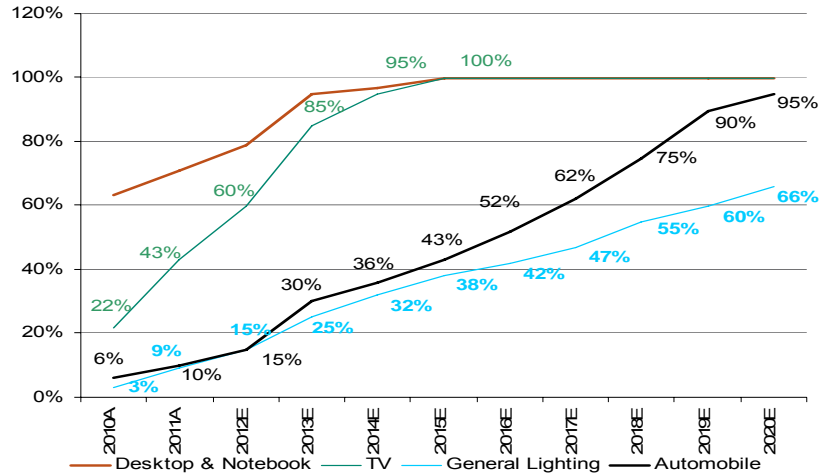
Source: BofA Merrill Lynch Global Research estimates

[Cross Reference](#)
[CREE, 02 July 2012](#)

Long-term LED growth from lighting

General lighting is the best-performing segment of the white LED market, and this should continue for the next several years. Falling prices, incentives combined with incandescent bulb limitations in some markets, and greater awareness of the economics of LED lighting are driving increasing penetration of the market. We expect general lighting LED to exceed the TV backlight market, currently the largest segment of demand, to become the biggest portion of total demand in 2014 or 2015. To look at it another way, we estimate that LED sales into lighting can double between now and 2014 even as the overall LED market shows little growth.

Chart 186: Historical and forecast penetration rates by end market



Source: BofA Merrill Lynch Global Research

Policy is focused on driving consumer change

As discussed above, many countries have released policy timelines that specify incandescent bulb phase-outs during the next five years. On the face of it, that should be good news for LED manufacturers. However, until the industry manages to hit the magic price point, which industry participants believe is US\$10-\$12, residential LED sales may not benefit much. Compact fluorescent lamps (CFLs) and cold-cathode fluorescent lamps (CCFLs) are priced more competitively and have been picking up residential share despite their less attractive light quality.

There are a lot of initiatives focused on phasing out incandescent light bulbs, although it's not clear how much LEDs will benefit in the near term

Chinese policy is notable for its focus on encouraging manufacturing investment

It is interesting to note that most policy tends to be focused on converting retail customers, which can have the biggest overall impact on power usage despite being the toughest proposition for buyers. In contrast, governments appear to recognize that LED lighting in commercial settings is an attractive proposition on its own, and there is less policy focus on driving change as a result. China is notable in that the government is providing an explicit incentive for manufacturing in the form of an MOCVD subsidy. That subsidy is scheduled to end soon, but our checks indicate that the Chinese government continues to support the development of domestic MOCVD tool capabilities.

Table 88: Regional lighting policy overlook

US	China	Europe	Japan
<p>The 110th United States Congress enacted Energy Independence and Security Act of 2007:</p> <ul style="list-style-type: none"> This act requires roughly 25% efficiency for light bulbs, phased in from 2012 through 2014. This effectively bans the sale and import of incandescent bulbs. This act requires all lighting in federal buildings to use Energy Star products. <p>The Department of Energy has initiated several activities to enhance lighting efficiency:</p> <ul style="list-style-type: none"> DOE has invested in R&D for solid-state lighting (SSL) – including both LED and OLED since 2003. 	<p>The NDRC and five other government departments jointly released a notice, focused on gradual phase out of imports, and sales of incandescent lamps:</p> <ul style="list-style-type: none"> Nov 2011 - Sep 2012: Transition period. Oct 2012 - Sep 2014: Lamps above 100 watts to be banned. Oct 2014 - Sep 2015: Lamps above 60 watts to be banned. Oct 2015 - Sep 2016: Mid-term evaluation period. Oct 2016 - Forward: Lamps above 15 watts to be banned. <p>Government financial incentives:</p> <ul style="list-style-type: none"> Local governments, such as Yangzhou, 	<p>European Union's phase-out of traditional light bulbs started in Sep, 2009. All incandescent and inefficient halogens will disappear from EU market by 2012.</p> <ul style="list-style-type: none"> Sep 2009: Incandescent light bulbs of 100W and above, and inefficient frosted (non-clear) bulbs of all wattages have been phased out. Sep 2010: 75W incandescent bulbs have been phased out. Sep 2011: 60W incandescent bulbs have been phased out. Sep 2012: 40 and 25W incandescent bulbs will be phased out. By the end of 2012: All inefficient light-bulbs phased out. 	<p>The government plans to submit a written request under the names of Economy, Trade and Industry Minister Yukio Edano and Environment Minister Goshi Hosono to major electronics retailers and home appliance makers, to voluntarily halt production and sales of energy-consuming incandescent light bulbs to save power this summer.</p> <p>The government aims to encourage people to use LED bulbs, which consume 80% less energy.</p> <p>Japan's existing basic energy plan stipulates that all commercially available lighting products be switched to LED or organic</p>

Table 88: Regional lighting policy overlook

US	China	Europe	Japan
<ul style="list-style-type: none"> States provides various financial incentives, including tax credits for interest on loans for energy efficiency and the Energy Efficiency Financing Program. <p>Post 2020, the backstop requirements will only be met by CFL or SSL - thus IRC/xenon halogen technology would appear to have an eight year window in the US market. Furthermore, new rulemaking is scheduled for 2014 to review and possibly amend these regulations, as well as requirements applying to CFLs, LEDs and OLEDs.</p>	<p>Jiangsu, subsidize RMB10 mn for each MOCVD tool. This subsidy is said to be terminated soon.</p> <ul style="list-style-type: none"> China's government will arrange a RMB2.2 bn subsidy to encourage usage of LED lighting and CFL lighting, and RMB26.5 bn to promote consumption of energy-saving appliances. The subsidy program is tentatively scheduled to run from 1 June 2012 to 31 May 2013. 	<p>EU rules require producers to mention on the packaging the lifetime of the lamp in hours, the number of the switching cycles the lamp is designed for, the colour temperature, the warm-up time and whether the lamp can be dimmed or not. EU governments provide guidance to consumers on how to purchase lighting products.</p>	<p>electroluminescence (OLED) lights by the year 2020, with the intention of reducing greenhouse gas emissions, and easing global warming.</p>

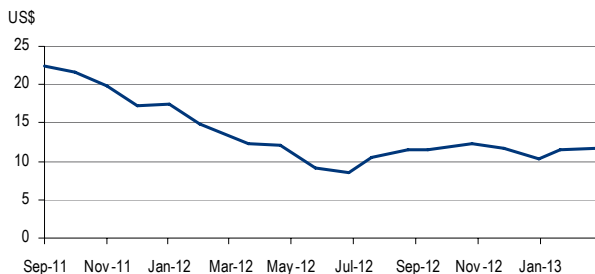
Source: Government official websites, BofA Merrill Lynch Global Research

LEDs are an increasingly attractive option

The current retail price gap between LED and CFL has narrowed to 5x from over 10x in 2010. As the cost continues to come down, and LEDs enable electricity cost savings, it has become a more attractive lighting option, especially in regions where electricity costs are high. Recent data points from Japan suggest a rapid surge in LED light bulb sales – and China's recent move to roll out a five year elimination of incandescents is set to be a major market growth driver. Cost parity is some years away, but we expect the market to grow rapidly when it arrives. In the meantime, Philips' predictions of 50% LED penetration by 2015 and 80% by 2020 look aggressive to us.

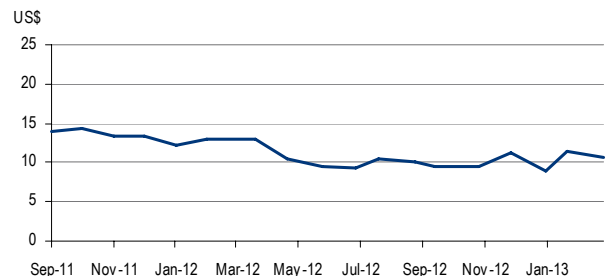
In February, prices of 40W LED light bulbs stayed flat and prices of 60W light bulbs declined by low-single digits due to the inclusion of a new, low-priced white brand in the US. In contrast, low-cost 60W LED light bulbs with price points at US\$9.99 from Lighting EVER are no longer available in the US. We noticed a substantial 10% reduction in the price of branded 40W LED light bulbs in the UK. China LED light bulb prices remained flat from January.

Chart 187: Retail price of 40W replacement LED bulbs in the US



Source: BofA Merrill Lynch Global Research

Chart 188: Retail price of 60W replacement LED bulbs in the US



Source: BofA Merrill Lynch Global Research ; non-brand 60W LED bulb

Commercial & industrial is the biggest target market

General lighting is an estimated by industry to be an US\$100bn market, 20% bulbs and 80% fixtures. Commercial and industrial lighting is the largest target market – with residential bulbs only constituting about 10% of the total market. Opportunities should arise via:

- **Leasing/spec vs. owner occupied.** LEDs are a more attractive proposition to building owners that occupy their premises because they look at the full cost. A problem arises when the owner has leaseholders because the owner bears the capital cost and maintenance burdens but the lessee pays the electricity bills, so there is little incentive for owners in these circumstances to upgrade the lighting system. Consequently, retail chains, hospitals, and government buildings are likely LED buyers.
- **New construction vs. retrofit.** The new construction market is small today but we expect to be heavily LED-driven in future, and this is where new features are most easily introduced. Retrofit is the opportunity today and is ROI-based. A two-year payback is attractive and one year too good to pass up.

Improved state of affairs in 2013

With LEDs in oversupply today, prices are under pressure while adoption is modest. As (1) vendor capex falls, supply will decline or at least grow less quickly, and (2) as technology improves and prices fall, adoption will be spurred. We think this improved state of affairs is more likely in 2013 than this year.

Competition comes in three buckets

Competition in LED lighting is threefold. First are the incumbents – Cree, Philips, Nichia, Siemens' Osram, Toyoda Gosei – which have strong technology. Second are the mid-power players, the Koreans and Taiwanese. Taiwan is moving into general lighting but is still at a brightness disadvantage. While the best Chinese are okay at best, and many reactors are gathering dust, there is a risk that larger Asian players may be willing to bear consistent losses.

Smart grid & energy storage, the ElectriNet

Table 89: BofAML Smart Grid & Energy Storage Stock List

Company	EE exposure
ITRON	High
MELROSE PLC	High
TOSHIBA CORP	High
ABB LTD	Medium
ALSTOM SA	Medium
CISCO	Medium
EATON PLC	Medium
JOHNSON CONTROLS	Medium
SCHNEIDER	Medium
GE	Low
SIEMENS	Low
SQM	Low

Source: BofA Merrill Lynch Global Research. * EE exposure = BofAML estimates of current sales derived from energy efficiency products, services, technologies and solutions

An overview of the smart grid issues raised in this section can be found in Andrew Hughes' Alternative Energy research

The smart grid represents the main segment of growth in the grid management industry for the next decade, in our view.

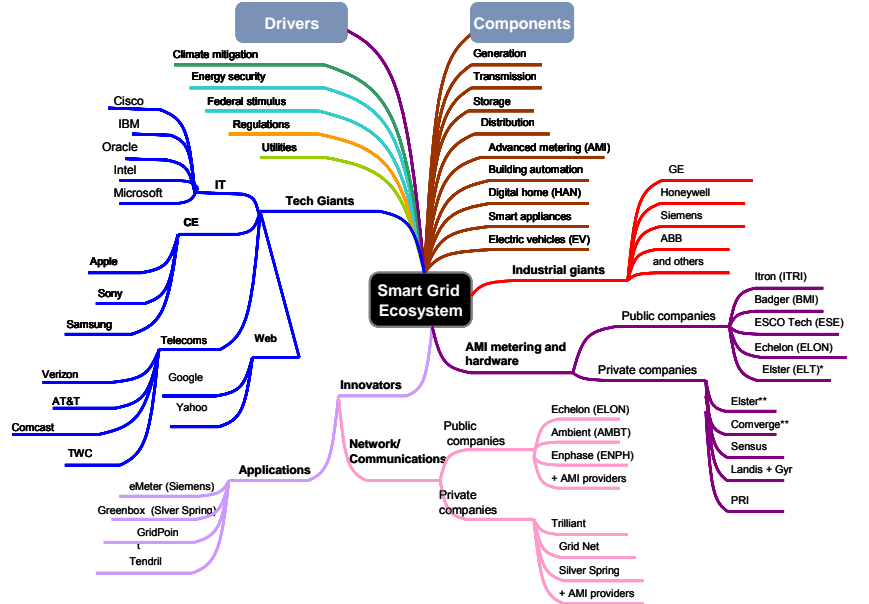
It is growing at an 11% CAGR from 2012-16E (source: Alstom) and our Alternative Energy team estimates it could represent a global market of up US\$63bn by 2020. Key market drivers include improving grid reliability and stability, increasing distributed generation, renewable energy integration (intermittency), reducing consumption peaks, increasing energy efficiency, EV integration, a greater focus on cyber security, and reducing CO2 emissions. The smart grid should also facilitate and improve prospects for greater energy efficiency in buildings, IT, power generation and T&D, and transport.

AMI – “internetization” of utility services. An important element of the smart grid is advanced metering infrastructure (AMI), including the rollout of smart electric, gas and water meters. Of the combined 2.7 billion electric, gas, and water meters worldwide, less than 15% are automated. While North America is expected to remain a leader, achieving 50% smart electric meter penetration this year opportunities in EMS – particularly in Asia – provide the greatest long-term upside, in our view. Based on announced projects alone, we expect more than 200 million meters to be installed in traditional markets by 2018 with the global smart meter market reaching US\$15bn.

Longer term, we believe that grid storage could be a technological breakthrough that could change how energy is produced, consumed and valued. Electricity storage is the ultimate goal of cleantech because it enables: (1) the electrification of transport, (2) the smoothing of renewable intermittency, and (3) the elimination of spatial and temporal price disparities. High cost remains an inhibitor to adoption near term, with utilities considering grid storage in demonstration projects, but we believe investors should become familiar with grid storage technologies and vendors.

We believe that a number of stocks are well placed to benefit from the theme of energy efficiency via smart grid and energy storage from their involvement in areas such AMI, automatic meter reading (AMR), batteries for grid storage, control rooms, customer-side systems, distributed grid management, electric vehicle (EV) charging infrastructure, ICT integration, li-ion batteries, network management systems, smart power electronics, renewables integration, substation automation, and wide-area monitoring and control.

Exhibit 2: Smart grid ecosystem

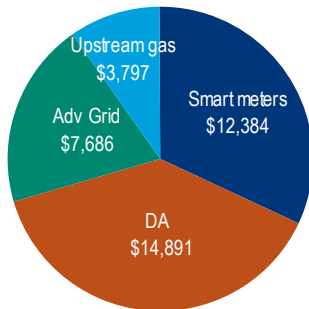


Source: Carbon-Pros, BofA Merrill Lynch Global Research
** Formerly publicly trade companies

Smart grid, a US\$63bn market by 2020E

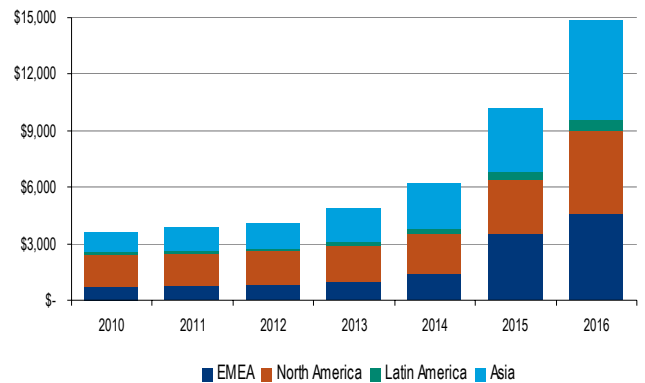
Today's electrical grids face many constraints from booming energy demand to ageing infrastructure, to lack of capacity, to hooking up distributed sources of generation. The network is under pressure to evolve into a high-performance electrical infrastructure, which integrates the energy T&D grid with embedded control, IT and telecommunication capabilities. Such a "smart grid" would ensure a better balance between energy production and consumption in a more complex operating environment.

Chart 189: 2016 forecasted smart energy market size by segment (US\$m)



Source: Industry sources, BofA Merrill Lynch Global Research estimates

Chart 190: Global distribution automation spending (US\$ mn)



Source: Industry sources, BofA Merrill Lynch Global Research estimates

Smart grid definition

According to the IEA, a smart grid is an electricity network that uses digital and other advanced technologies to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end-users. Smart grids co-ordinate the needs and capabilities of all generators, grid

operators, end-users and electricity market stakeholders to operate all parts of the system as efficiently as possible, minimising costs and environmental impacts while maximising system reliability, resilience and stability.

Traditional grid vs smart grid

Factor	Traditional grid	Smart grid
Communication	One-way	Two-way
Interaction with consumers	Minimum	Extensive
Meters	Mechanical	Digital
Management	Manual	Automated
Supported power generation	Concentrated generation	Concentrated + distributed generation
Reliability	Prone for failure	Automated protection
Recovery	Manual	Self-healing
Shape of the grid	Emission pattern	Net pattern

Source: BofA Merrill Lynch Global Research

Smart grid technologies

Smart technologies span the entire grid, from generation through transmission and distribution to various types of electricity consumers – industrial, residential and consumers. Some of the technologies are actively being deployed and are considered mature in both their development and application, while others require further development and demonstration. In terms of the companies that stand to benefit, they include large diversified conglomerates with T&D and smart grid activity (Alstom, GE and Siemens), smart meter/grid pure play companies, and companies looking to link to smart grid technology (auto, buildings, IT).

Cross Reference

[Alternative Energy, 10 September 2012](#)

Looking past the meter to a smarter grid

Our Alternative Energy team's analysis of the smart energy market specifies four types of supply-side investment – distribution automation (DA), advanced grid projects, smart meters, and upstream measurement and monitoring equipment for gas. Upstream smart energy applications like DA and advanced grid projects should account for US\$26bn in spending by 2016, 3x 2012 levels [BofAMLe]. Managing and interpreting the deluge of data generated by advanced metering infrastructure will be a key challenge.

Asia emerging as primary demand centre

Over time, we see Asia emerging as the primary demand centre for upstream smart energy projects, but we also expect demand from North America. We think that smart energy plans among European utilities mandated by Euro 2020 are under less threat from the continent's macro situation than the market anticipates, and we expect vendor selection to begin for some projects this summer.

Few pure plays, growing exposure at large companies

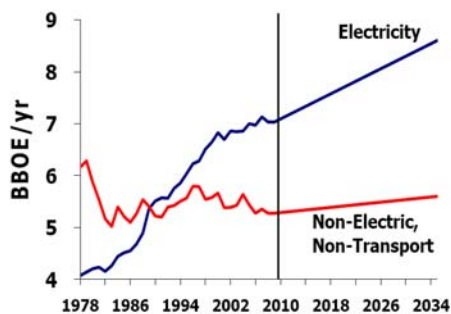
Identifying pure-play companies that focus exclusively on smart energy infrastructure is difficult. Major equipment and software providers have been aggressive in buying smaller firms to build out their product offerings, meaning that there are not many opportunities like Itron left. We note that Itron's competitor Elster was recently bought by Melrose PLC. The good news is that we consider the US\$40bn market opportunity large enough to become meaningful even for the larger companies we have identified.

Table 90: Overview of smart grid technology chain

Technology	Hardware	Software	Grid impact	Maturity	Development
Wide-area monitoring and control	Phasor management units (PMU), sensor equipment	Supervisory control and data acquisition (SCADA), Wide area monitoring systems (WAMS), Wide-area adaptive protection control and automation (WAAPCA), Wide-area situational awareness (WASA)	Generation, transmission	Developing	Fast
Information and communication technology integration	Communication (power line carrier, WIMAX, LTE, RF mesh network, cellular), routers, relays, switches, gateway, servers	Enterprise resource planning software (ERP), customer information system (CIS)	Generation, transmission, distribution, industrial, service, residential	Mature	Fast
Renewable & distributed generation integration	Power conditioning equipment for bulk power and grid support, communication & control hardware for generation and enabling storage technology	Energy management system (EMS), distribution management system (DMS), outage management system (OMS), workforce management system (WMS)	Generation, transmission, distribution, industrial, service, residential	Developing	Fast
Transmission enhancement	Superconductors, FACTS, HVDC	Network stability analysis, automatic recovery systems	Transmission	Mature	Moderate
Distribution grid management	Automated re-closers, switches & capacitors, remote controlled distributed generation & storage transformer sensors, wire & cable sensors	Geographic information system (GIS), DMS, OMS, WMS	Distribution	Developing	Moderate
Advanced metering infrastructure (AMI)	Smart meter, in-home displays, servers, relays	Meter data management system (MDMS)	Distribution, industrial, service, residential	Mature	Fast
Electric vehicle (EV) charging infrastructure	Charging infrastructure, batteries, inverters	Energy billing, vehicle-to-grid charging (V2G), discharging V2G methodologies	Distribution, industrial, service, residential	Developing	Fast
Customer side systems	Smart appliances, routers, in-home display, building automation systems, thermal accumulators, smart thermostat	Energy dashboard, energy management systems, energy applications for smart phones and tablets	Industrial, service, residential	Developing	Fast

Source: Companies, BofA Merrill Lynch Global Research

Chart 191: US energy consumption (ex-transport; BBOE/yr)



Source: U.S. Department of Energy, Energy Information Administration

Strong long-term drivers for the smart grid

Smart grids have the potential to be a game changer in terms of reducing peak demand, better managing generation from both variable and dispatchable sources, and reducing the potential increases in capex costs. Operating savings can come from decreased costs for maintenance, metering and billing, and fuel savings through increased efficiencies and other areas. Energy consumption in the form of electricity has risen 75% in the past 30 years. IEA and U.S. EIA forecast that the trend will continue for another 30 years. Below we show the advantages of a smart grid in the context of rising electricity usage:

- **Accommodates all generation and storage options:** from large centralised power plants to customer-sited, intermittent distributed energy resources (renewables, CHP, energy storage, EVs).

9% of electricity supplied globally is lost through transmission and distribution

Smart grid technologies could enable 0.7-2.0Gt of net annual CO2 emissions reductions by 2050

- **Optimises asset utilization and operating efficiency:** applies the latest technologies to optimize the use of its assets (eg, optimised capacity via dynamic ratings, maintenance efficiency via condition-based maintenance).
- **Ensures grid reliability and stability:** the ability to react to unexpected events such as blackouts, disturbances, attacks and natural disasters, by isolating problematic elements while the rest of the system is restored to normal operation.
- **Provides power quality for a range of needs:** according to varying grades and prices of power (ie, residential customers vs commercial enterprises).
- **Informed participation by customers:** modifications in the way motivate different purchasing patterns and behaviour.
- **Enables new products, services and market:** creating an opportunity for consumers to choose among competing services via variables such as energy, capacity, location, time, rate of change and quality.

Huge scope for efficiency & emissions improvements

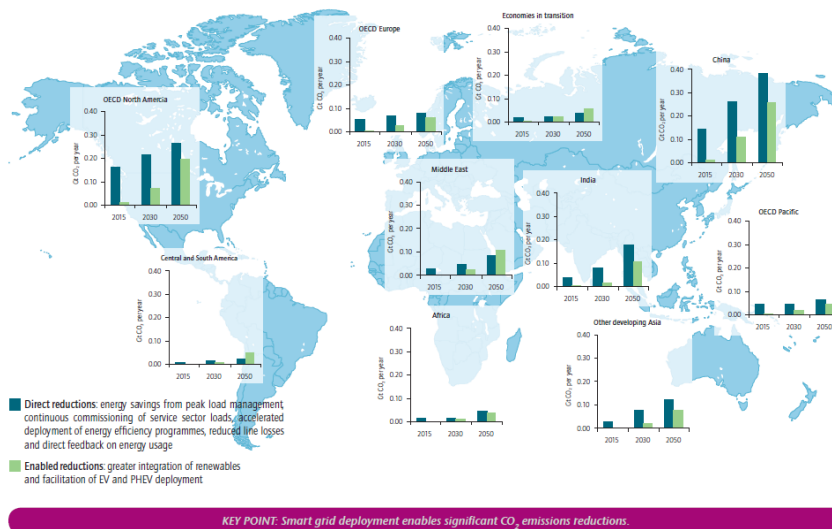
Smart grid technologies are key potential enablers of a more efficient T&D grid and reduced CO2 emissions:

- **Direct CO2 emissions reductions:** through feedback on energy usage, lower line losses, accelerated deployment of energy efficiency programmes, continuous commissioning of service sector load, and energy savings from peak load management.
- **Indirect benefits:** arise from smart grid support for the wider introduction of EVs and variable renewable generation.

Under the IEA's ETP Blue Map Scenario (IEA scenario target-oriented which sets the goal of halving global energy-related CO2 emissions by 2050 vs 2005 levels), electricity generation would only contribute 21% of global CO2 emissions (vs 40% today), representing an annual reduction of over 20 Gt of CO2 by 2050. Smart grids offer the potential to achieve net annual emissions reductions of 0.7 Gt to 2.1 Gt of CO2 by 2050. North America shows the highest potential for CO2 emissions reduction in the OECD, and China among non-OECD countries.

Exhibit 3: Regional CO2 emissions reduction from smart grid deployment [can we reformat this to be more ML friendly?]

Figure 13. Regional CO₂ emissions reduction from smart grid deployment



Source: IEA

AMI - “internetization” of utility services

An important element of the smart grid is advanced metering infrastructure (AMI), including the rollout of smart electric, gas and water meters. Of the combined 2.7 billion electric, gas, and water meters worldwide, less than 15% are automated. Penetration rates vary widely across segments and geographies, led by North America’s electric meter market. Our Alternative Energy team estimates that there are 1.2 billion electricity meters installed worldwide – with smart meters accounting for around 20% of the installed base.

Table 91: Electricity meters – basic and smart penetration 2010-20E

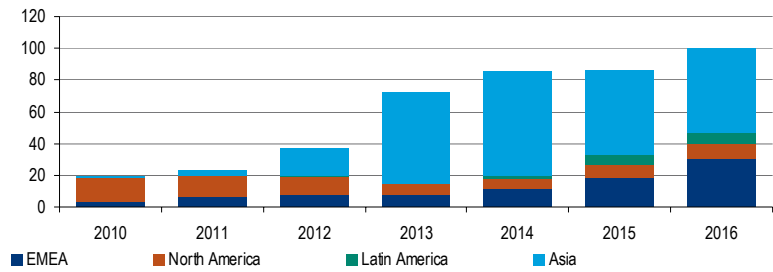
No of meters (million)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Electricity	1,278	1,424	1,583	1,743	1,907	2,057	2,221	2,390	2,566	2,720	2,867
Basic	1,065	1,145	1,209	1,279	1,343	1,400	1,450	1,496	1,537	1,572	1,601
Smart	213	279	373	464	564	657	770	893	1,029	1,149	1,266
smart penetration	16.7%	19.6%	23.6%	26.6%	29.6%	32.0%	34.7%	37.4%	40.1%	42.2%	44.2%

Source: BofA Merrill Lynch Global research estimates * Basic electricity meters are defined as basic and one-way advanced meters, Smart electricity meters are defined as two-way and smart two-way meters per IMS definition

Asia the long-term driver

Demand for meters and related communications is primarily driven by growth in AMI. Smart meter activity to date has focused primarily on North America, Western Europe and East Asia. According to industry estimates, 95% of the world’s metering base is installed across those three markets, representing a significant replacement and upgrade business for incumbent metering companies. North America is expected to remain a leader, achieving 50% smart electric meter penetration this year, though opportunities in EMs – particularly in Asia – provide the greatest long-term upside, in our view.

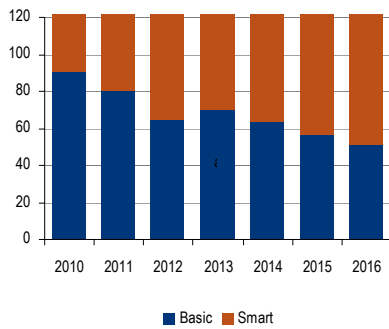
Chart 192: Annual two-way smart meter installations



Source: BofA Merrill Lynch Global Research

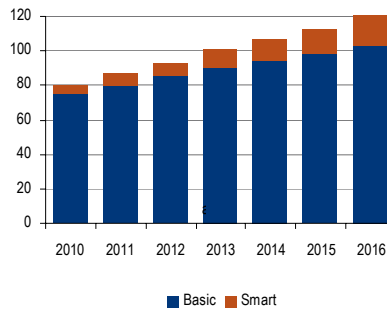
Based on announced projects alone, we expect more than 150 million meters to be installed in traditional markets by 2018, which does not even include large markets such as China. (China has closed its residential meter market to foreign vendors but allows C&I sales.) The European Union has a mandate to upgrade 80% of electric meters by 2020 (Sweden and Italy have already achieved this).

Chart 193: Global Electricity smart vs basic



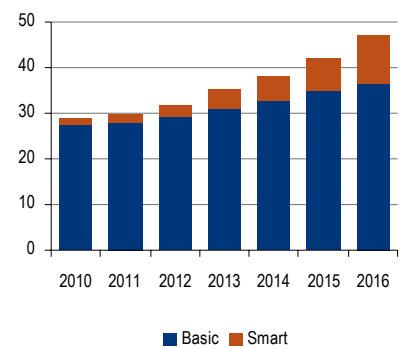
Source: BofA Merrill Lynch Global Research

Chart 194: Global Water smart vs basic



Source: BofA Merrill Lynch Global Research

Chart 195: Global Gas smart vs basic



Source: BofA Merrill Lynch Global Research

Potential for 200-400 million global installations by 2020

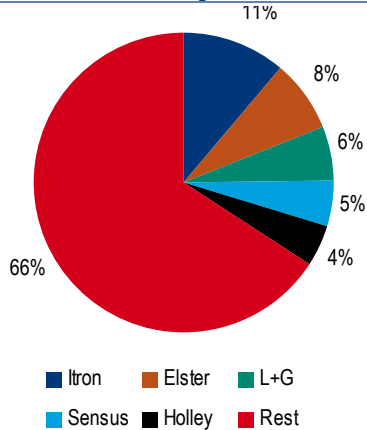
Substantial opportunities also exist outside of traditional markets. In a study of 25 emerging smart meter markets, Northeast Associates found potential for 406 million meter installations by 2020. Some 28% of that total is legislatively mandated, meaning a minimum of 115 million meters across countries in Eastern Europe, the Middle East, Southeast Asia, and Latin America ex-Brazil.

Exhibit 4: International smart meter rollout calendar

Country/Utility	2011	2012	2013	2014-2018	2019+
EUROPE					
England					50m meters by 2019
E.ON		300k meter rollout			
British Gas		400k of 2m meters installed by Q1 2012			
Scottish/Southern		Rollout begins			
Spain				100% by 2018 mandate	
Endesa				13m meters by 2018	
Iberdrola	300k deployed by Q1 2012		1m by early 2013	10.5m meters by 2018	
France				35m by 2018	
ERDF		7m meter rollout delayed by election			
GRDF (gas)				11m meter rollout 2013 2018	
Germany		Pilots	Rollouts expected	25m by 2017 expected	32m by 2020 required
Italy	Residential installation largely complete (Enel)			2016 C&I project	
Netherlands		Initial deployment			
ASIA-PACIFIC					
Japan		3m meter tender Q1 2012			15m by March 2019, 75m by 2023
TEPCO		Request for comments			32 million meters by 2022
Korea		Pilots determined		10m by 2016	27m meters by 2020
China	AMR rollout	AMI transition begins		AMI rollout	
India		Pilot for 87k meter		AMI rollout	
LATIN AMERICA					
Brazil		65m meter rollout begins			68m meters by 2020
Light SA	20k rollout*				
Electrobras	14.5k rollout				
TOTAL					235m+ meters by 2020

* Denotes projects to which Elster will provide meters and/or communications and networking
Source: Industry sources, BofA Merrill Lynch Global Research estimates

Chart 196: Global metering market share



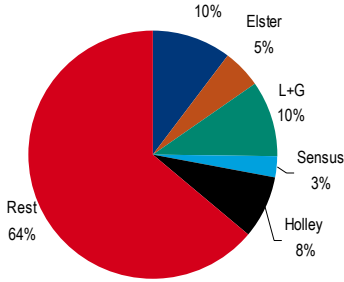
Source: BofA Merrill Lynch Global Research

AMI/AMR competitive landscape

There is a variety of actors in the smart meters to smart software space, and a large and rapidly growing constellation of small and large companies entering the fray. They are all in a race to become major players in the enormous market to apply the communications, sensors, computing, and software muscle of the digital age to enable a 21st century ElectriNet:

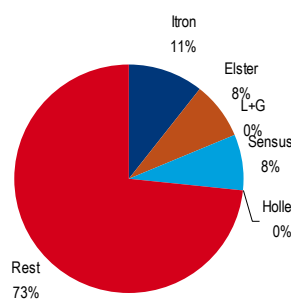
- **Manual and AMI/AMR meter manufacturers** include General Electric, Itron, Elster (now part of Melrose), Landis+Gyr (now part of Toshiba), Sensus, Silver Spring Networks and Panasonic (partnership with Itron in Japan). On the electric meter communications front, independents include Trilliant and SmartSynch.
- **Electricity metering** players include Itron, Landis+Gyr and Elster, as well as GE, Silver Spring, and Sensus in the North American smart meter space.
- **The gas meter market** includes the leader Elster (c.22% share) and Itron along with Dresser and Emerson at the high end, Honeywell in utilization, and Toshiba in residential. We note that customer relationships in the gas segment are particularly sticky as a result of the serious safety concerns associated with gas extraction, storage, transmission and use.

Chart 197: Global Electricity Meter Market



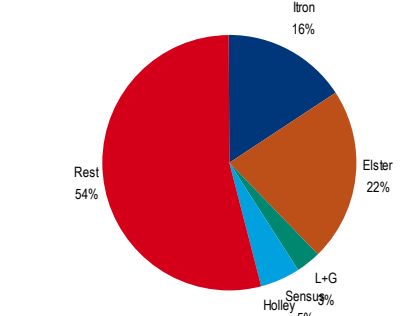
Source: BofA Merrill Lynch Global Research

Chart 198: Global Water Meter Market



Source: BofA Merrill Lynch Global Research

Chart 199: Global Gas Meter Market



Source: BofA Merrill Lynch Global Research

Cross Reference - Global Water
Thematic Investing, 14 December 2012

- **Water meters** – Itron and Elster are major players in the space. There is long-term potential for water, in our opinion, given the rising challenges posed by water scarcity globally and the fact that water is unmetered in most parts of the world.

Table 92: Recent water metering projects

Vendor	Segment	Utility	Location	Project type	Customer end-points
Honeywell	Water	Ministry of Electricity and Water	Kuwait	Distribution automation	
Itron	Water	Aguas de Valencia	Spain	Meters + communication	100,000
Survalent	Water	Winnetka	Illinois	Advanced grid	
MeterSense	Water	MAWSS	Canada	Advanced grid	
Elster	Water	SANEPAR	Brazil	Meters	105,000
Itron	Water	Las Vegas Valley Water District	Nevada	Meters + communication	400,000
Itron	Water	San Diego Public Utilities	California	Meter communications	11,000
Landis + Gyr	Water	Lower Yellowstone REA	Montana	Meter communications	
WaterSmart Software	Water	various OC water munis	California	Advanced grid	
Elster	Water	SABESP	Brazil	Meters	193,000
Elster	Water	SABESP	Brazil	Meters	193,000
MeterSense	Water	Albuquerque County Water	New Mexico	MDM	
Itron, Manas Energy Management	Water	Kocaeli Water and Sewage	Turkey	Meters + MDM	1,000
Itron	Water	Victoria State Water Utilities	Australia	Meters + communication	
LightRiver	Water	State of CA Water Resources	California	Communications	
Itron	Water	Water Corporation of Australia	Australia	Meters	13,000
Elster	Water	Sharjah Electricity and Water	Sharjah	Meters	33,000
Elster	Water	Melbourne Regional Water	Australia	Meters	300,000
Elster	Water	COPASA	Brazil	Meters	120,000
Itron	Water	Servicii Comunale Floresti	Moldova	Meters + communication	11,000
Corix Utilities	Water	United Water	New Jersey	Meters	192,002
Itron	Water	Sydney Water	Australia	Meters	4,600,000
Itron	Water	Aqua America	USA	Communication	600,000
Elster	Water	PUB Singapore	Singapore	Meters	240,000
Elster	Water	Consorcio de Aguas de Bilbao	Spain	Meters + communication	42,000
Itron	Water	PDAM	Indonesia	C&I meters	39
Elster	Water	Macao Water Supply Company	Macao	Meters	41,000
Itron	Water	Cairns Regional Council	Australia	Meters	
Itron	Water	Madison Water Utility	Wisconsin	Meters	235,000
Elster	Water	Wide Bay Water Corporation	Australia	Meters + communication	
Elster	Water	EMASESA	Spain	Meters	

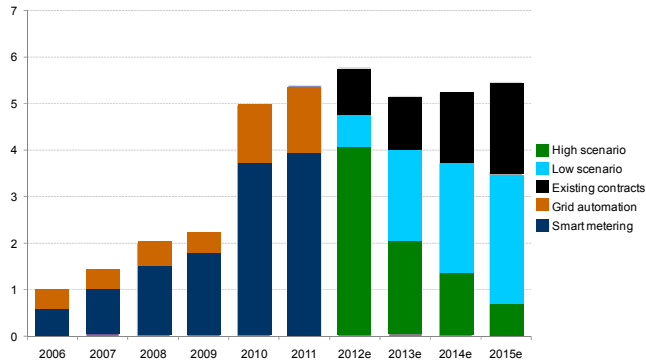
Source: Company, BofA Merrill Lynch Global research

North America, an US\$11.9bn market by 2016E

We believe that smart energy has the potential to resume rapid growth, and that the market could expand from US\$5.3bn in 2012 to US\$5.4bn in 2013 and US\$11.9bn by 2016, almost exclusively driven by DA, advanced grid and gas

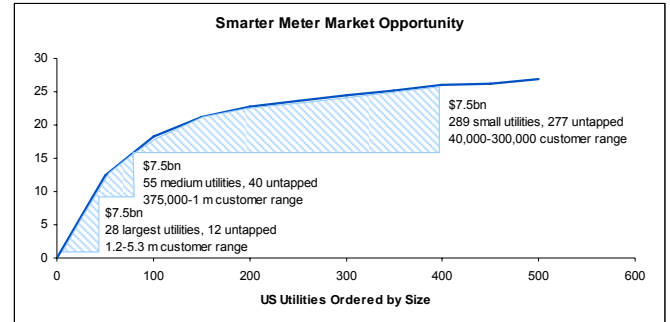
spending. The early surge of smart meter deployment, especially in the US, is fading, but investment in distribution automation and advanced smart grid projects is expanding. At the same time, the smart meter market is expected to shift from the traditionally strong US market to Asia and Europe where regulatory regimes across both continents should drive meaningful growth. The outlook for water meters looks grim. We expect the segment to remain flat and anticipate a particularly difficult year in North America as state and local budgets face well-documented deficits.

Chart 200: North American electricity market peaking (US\$bn)



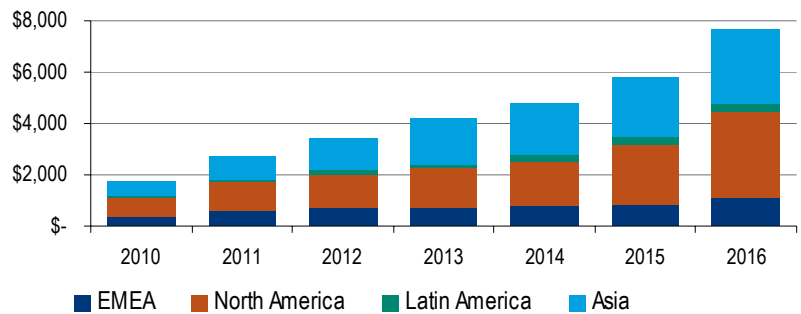
Source: BNEF

Chart 201: Smart meter opportunity shifting to smaller utilities



Source: BNEF

Chart 202: Global advanced grid spending (US\$mnn)



Source: Industry sources, BofA Merrill Lynch Global Research estimates

2013 and beyond

EU - all signs suggest programmes are proceeding

We acknowledge that under existing macro circumstances, the EU target of 80% smart electricity meter coverage by 2020 could be considered optimistic. Still, all the indications are that these programmes are proceeding. When the French rollout is complete, for instance, the country will have exceeded the Eurozone target. We believe there is substantial opportunity for a European company with a large footprint on the continent to capitalize on the 100 million meters the European Commission expects to be installed by 2015. We view projects by Italian utility Enel, Spanish utility Iberdrola, and British utility E.ON – as well as expected announcements of additional awards in Spain and France this summer – as evidence that the continent is moving forward.

Brazil and Russia – considerable opportunities

There are also substantial electricity metering opportunities outside Europe. Russia is planning to replace 48 million residential meters before 2020. In Brazil, there are 10 electric utilities that suffer from 15%-plus non-technical losses and are vociferous advocates of the government’s 65-million smart meter rollout planned for the next 10 years. In fact, Northeast Associates estimates the emerging market at 115 million smart meters on the low end, exclusive of Russia and Brazil.

Asia – smart energy hotspot

Asia has emerged as the smart energy hotspot, and we expect it to be a US\$20.2bn market by 2016 – nearly double the size of North America. The emergence of Chinese and Japanese smart meter manufacturers, the challenges of energy demand and delivery in India and Japan, and the rapid growth in solar installations across the entire continent are the key differentiators of the region.

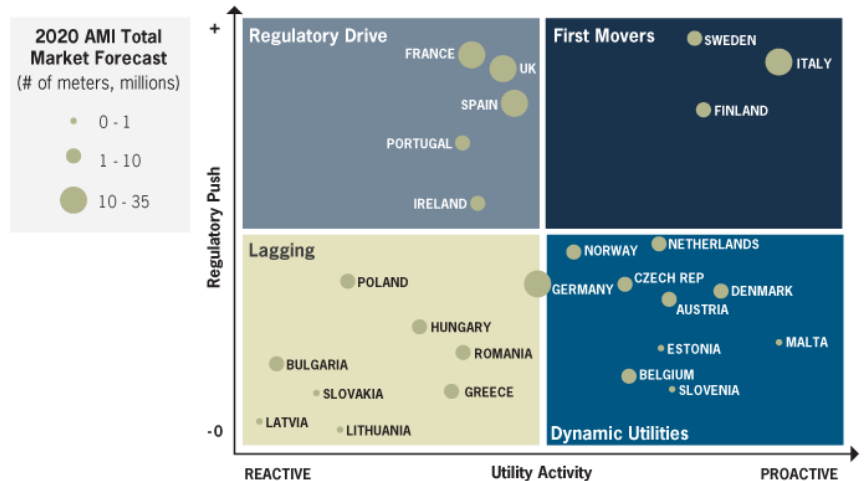
Cross Reference - Global Water

Thematic Investing, 14 December 2012

Water scarcity and quality will spur replacement and upgrades

We expect drought and water quality issues to spur regulatory action with a focus on conservation and improving quality standards to drive meter replacement and upgrades. For example, Saudi Arabia recently announced US\$66bn worth of water and wastewater projects to occur over the next eight years. China also plans to invest in water conservation (US\$12.5bn).

Chart 203: Additional catalysts include forthcoming announcements from Iberdrola (Spain), ERDF (France) as well as utilities in Portugal, Ireland and Germany



Source: BofA Merrill Lynch Global Research

Enel’s success demonstrates the value of a large rollout

The Telegestore project, launched in 2001 by Enel in Italy remains the largest and most successful AMI and smart grid project to date. Enel installed 33 million smart meters (including system hardware and software architecture) and automated 100,000 distribution substations, while also improving management of the operating workforce and optimising asset management policies and network investments. The project has resulted in fewer service interruptions and its €2.1bn investment has led to actual cost savings of over €500mn/year.

Enel’s €500mn in annual cost savings demonstrates the value of a large-scale, integrated deployment of smart grid technologies

Table 93: Benefits of AMI rollout

Stakeholder	Opportunities	Challenges
Utilities	Potential to reduce peak demand, better manage generation from variable and dispatchable sources – thus reducing capex costs Opex cost savings via decreased costs for maintenance, metering and billing, fuel savings via efficiencies	Deployment of nextgen (eg variable generation) and end-use technologies (EVs) could increase capex costs Behavioural aspects of electricity usage have not been sufficiently researched
Consumers	Help manage energy use by taking advantage of lower off-peak prices, for example	

Source: BofA Merrill Lynch Global Research

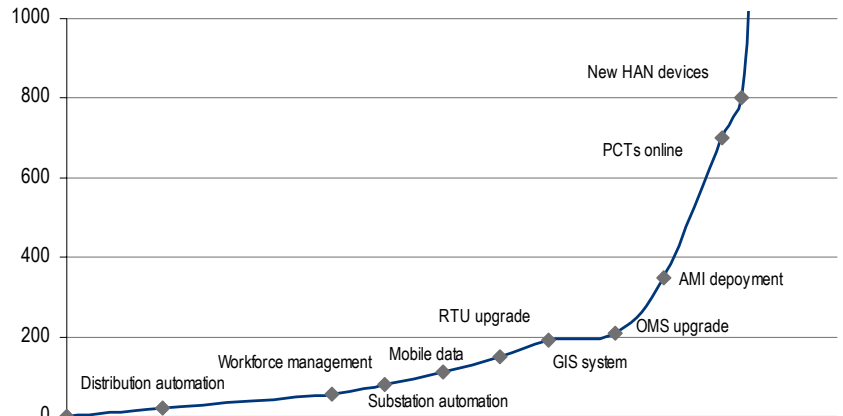
Cross Reference

Itron, 10 September 2012

Managing the AMI data deluge

Demand for enterprise-wide meter data management (MDM) solutions – such as Itron’s – should grow, based on inadequate IT infrastructure at most utilities worldwide. A recent industry survey revealed that 64% of utilities consider translating smart data into actionable strategic and revenue generating decisions a top priority. Currently, only 46% of utilities with existing smart grid programs have MDM systems in place. Moreover, 60% of utilities with an active MDM system silo data within the metering department, meaning they miss the opportunity to communicate useful information to customers.

Chart 204: Smart grid data volume growth for utility with 1 million customers (terabytes)



Source: EPRI, BofA Merrill Lynch Global Research estimates

64% of utilities surveyed by EPRI say that translating smart data into actionable strategic decision making is one of their top three priorities.

According to the Electric Power Research Institute (EPRI), a single smart meter reporting usage data at 15-minute intervals generates roughly 400MB of data per year. Expanded across a million meters, the terabytes worth of information a smart grid project produces can overwhelm utilities with even the most sophisticated internal data management systems. As a utility invests in additional smart grid services, the data deluge increases exponentially. As the smart energy market migrates upstream and around the globe, in our opinion there is substantial opportunity for Itron’s MDM expertise.

Drivers for smart meter installation

Historically, the primary impetus for the installation of smart gas, electric, and water meters has been to reduce the cost of manual meter reading. A key driver of the next phase of metering, especially in developed markets, will be distribution automation (DA), the ability of a utility to extend communication and intelligent

control capabilities to the transmission and distribution grid. DA allows utilities to influence electricity – and feasibly gas and water – flows and usage without entering a customer’s home or business. This should prove especially popular in countries where a backlash over smart metering safety and security concerns has slowed adoption. We also expect energy conservation and peak consumption reduction to be important drivers as time-of-use pricing becomes more prevalent.

Many challenges remain

- **Business case** The transition to automated meter reading (AMR) was relatively smooth given the tangible benefits of wireless reading. The case for Advanced Meter Infrastructure (AMI) has been less clear. IOUs, which are heavily regulated, need revenue decoupling for upgrades to be attractive. Public power companies, however, generally are not generators and find AMI more compelling. Some benefits of AMI’s two-way capability include gaining outage information, allowing for disconnects, and providing prepayment capability (popular not just among low income households).
- **Capex requirements:** Despite the potential cost savings and [good] ROI, smart grid implementation does require significant capital spending, which some already-pressed utilities could hold back on if the current economic climate does not improve.
- **Consumer adoption and rates:** For many consumers who have never heard of the smart grid, their only concern lies in the costs of deploying the smart grid, and utility retail rate increases.
- **Data management:** With a smart grid, utilities will have a never-ending stream of data. The question remains as to whether such data can/will be used to optimise the grid or will simply overwhelm utilities and their customers.
- **Emerging markets:** While smart grids can play an important role in deploying new electricity infrastructure by enabling more efficient operation and lower costs, we must remember that many EM grids do not operate consistently 24-7 (or lack electricity infrastructure). This necessitates tailoring grids, for example via small “remote” systems in rural areas.
- **Partnerships:** Utilities will increasingly be seen as clean energy system integrators but merging smart grid infrastructure with legacy grids will be challenging and involve partnerships across the grid.
- **Return on investment.** Analysing the cost-benefit equation for the smart grid can be difficult. Estimates for cost savings are plentiful, but the actual deployments and ROI theories do not always line up.
- **Cyber security.** Smart grids will be networked, which means cyber attacks are possible. We see cyber [crime] as one of the key threats in the coming years with the grid likely to face increasing risks.
- **Standards and interoperability.** Different smart grids use different national, regional or industry standards, creating a pressing need for interoperability standards across all key interfaces so that utilities can buy functional equipment from any vendor. Different standards across Europe appear to be driven by varying: (1) physical footprints – wiring standards etc with new meters typically having to fit into existing holders; (2) functionality requirements (memory requirements for example); (3) interference and communication standards; and (4) designs standards – appearance of the register, optical standards, branding etc.

Cross Reference - Safety & Security

[Thematic Investing, 26 September 2012](#)

Cross Reference

[Melrose plc, 4 March 2013](#)

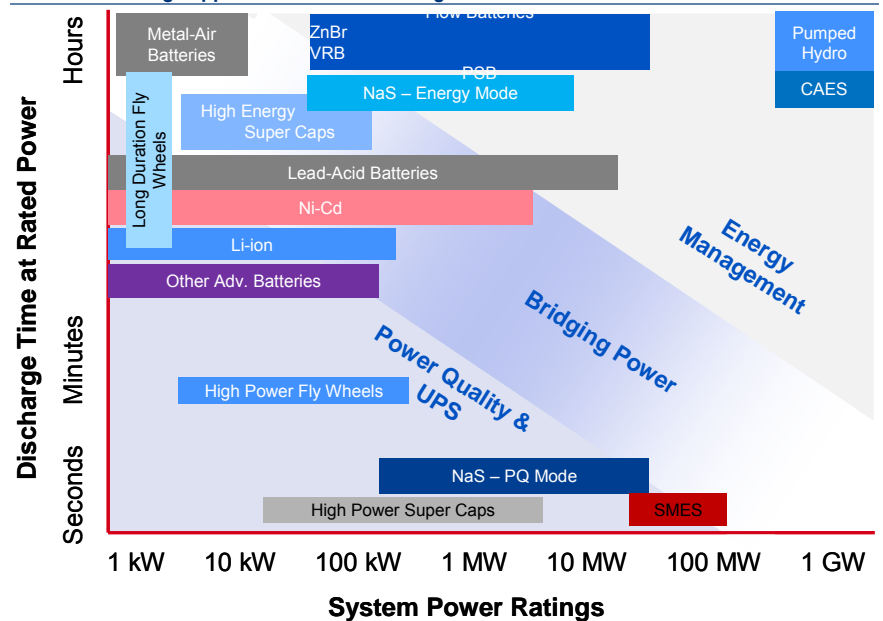
- **Uphill battle for a disruptive technology:** We consider demand response one of the most disruptive approaches to cleantech given the attractive economics of efficiency. This approach, however, can attract criticism from traditional generators, which are sometimes trying to slow demand response penetration.

Grid storage, missing piece of the ElectriNet

The balancing of electricity demand and supply is becoming more difficult. With structural changes in how we consume and generate power, including intermittent renewables and electric vehicles, the development of grid-scale electricity storage will be an essential component in building the smart grid of the future.

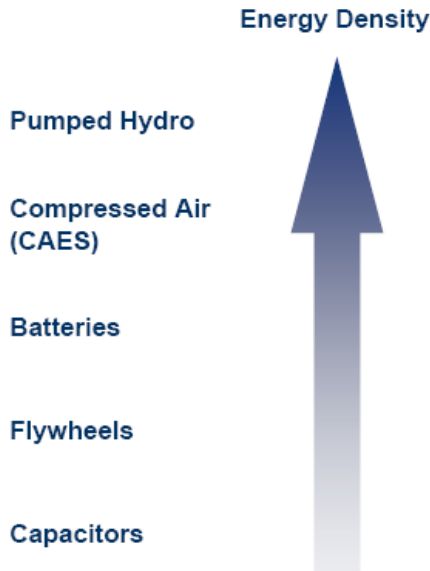
Recent technological and manufacturing advances in capacitors, batteries, and flywheel storage have spurred increased investment in the space. While it is early days and costs are high, the market opportunity for these technologies could be well over US\$10bn according to industry estimates.

Chart 205: Storage applications and technologies



Source: U.S. Department of Energy

Chart 206: Storage technologies by density



Grid storage needed for cleantech to realize its potential

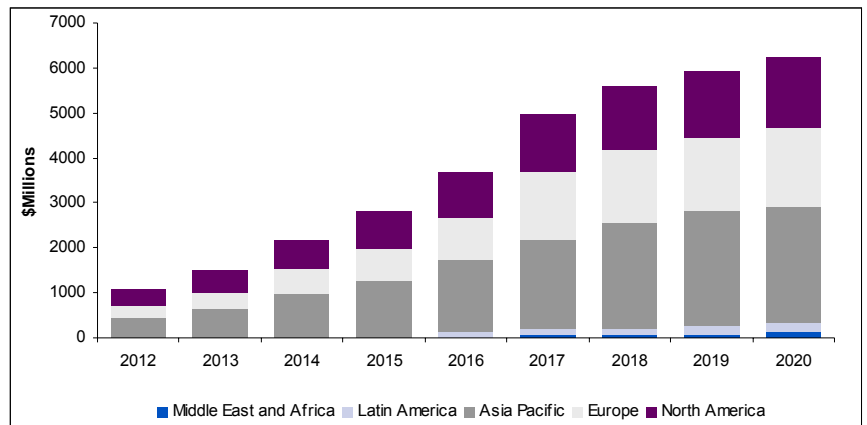
Harnessing the ability to store electrons at grid scale has the potential to mark a technological breakthrough that could change how energy is produced, consumed, and valued. Many consider electricity storage to be the ultimate goal of cleantech because it enables:

- **Electrification of transportation** – ie, vehicle-to-grid (V2G) technology which will enable electric vehicle (EV) owners to sell demand response services to grid operators through their vehicle’s battery when plugged into a charging system.
- **Smoothing of renewable intermittency**, for utility-scale storage projects, particularly relating to wind where with system penetration rates of 20%, intermittency becomes a real threat to overall system stability that only storage can address.
- **Elimination of spatial and temporal price disparities.**

High cost remains an inhibitor to adoption in the near term, with utilities considering grid storage in demonstration projects. However, we believe investors should become familiar with grid storage technologies and vendors.

Storage facilitates the management of electricity

Chart 207: Smart grid data analytics spending is on the rise



Source: C3 Energy, Pike Research

Storage was the unsung hero of the Internet revolution and likewise we think will play a critical role in establishing the “ElectriNet,” making the smart grid a reality. Batteries will be found at four levels of the network: neighbourhoods, local loop (microgrids), substations, and head-end (generation).

Distributed storage offers advantages over centralized storage

We think distributed, or Community Energy Storage (CES), offers an advantage over centralized storage. Local capture and discharge of electricity (1) reduces line losses, (2) promotes targeted and efficient dispatch capability, (3) provides greater flexibility in handling multiple applications, and (4) enables on-site/parallel management of intermittent renewables and electric vehicles.

Table 94: Energy storage applications

Category	Applications
Electric Supply	Electric Energy Time-Shift Electric Supply Capacity
Ancillary Services	Load Following Area Regulation Electric Supply Reserve Capacity Voltage Support
Grid Systems	Transmission Support Transmission Congestion Relief T&D Upgrade Deferral Substation On-site Power
End User	Time-of-use Energy Cost Management Demand Charge Management Electric Service Reliability Electric Service Power Quality
Renewables Integration	Renewables Energy/Time Shift Renewables Capacity Firming Wind Generation Grid Integration

Source: Sandia National Lab (U.S. Dept of Energy)

Multiple levels of storage applications

Energy storage applications fall into five categories: electric supply, ancillary services, grid system, end user, and renewables integration.

Ancillary services, the most immediate revenue opportunity

The most immediate revenue opportunity appears to be in ancillary services, which cover the functions performed by grid operators to ensure reliability of control areas and the interconnected transmission system. Examples include load following, area regulation, and voltage support, which deliver 10-20% of electricity output, equating to billions of dollars. Ancillary services vary in terms of required power and energy density by application. Reserve capacity and load following can require considerable power and energy density qualities, similar to the energy supply category. By contrast, area regulation and voltage support can be served by storage assets with a fraction of the aforementioned capability.

Grid system, end user support and, eventually, renewables integration should follow. We believe that integration of intermittent renewables should begin within the decade. Pure market pricing arbitrage, eliminating the price gap between on-peak and off-peak periods, is likely to be many years away and will require significant technology advances.

Technologies must be matched to the right use

Since there is no single storage technology winner, matching solutions to their appropriate use will likely be important. Is the goal improved power quality and uninterrupted power supply, bridging power, or energy management? Similarly, system balance among energy and power, cycling, and usage cost is important. Pumped hydro and compressed air storage can time-shift at the generation level. Batteries and flywheels, though expensive today, offer quick response times for frequency regulation and renewables integration. Flow batteries and ultra-capacitors also have roles to play.

Overview of grid storage technologies

Technology	Overview	Deployment & cost
Pumped hydroelectric energy storage (PHES)	During off-peak periods when energy prices are low, water is pumped from a lower reservoir to another reservoir at a higher elevation. When energy demand is high, water is discharged from the upper reservoir then passes through turbines that convert the gravimetric energy into electricity.	Widely deployed storage technology with 38 facilities in the US with a combined 22GW of capacity Most cost-effective means of storing large amounts of electrical energy on an operating basis, but capital costs and the environmental impact are critical decision factors.
Compressed air energy storage (CAES)	Purchase electricity during off-peak periods, store the output in a produced physical form, and then release physical energy to recreate electricity at higher value, on-peak periods. CAES systems compress and pump surface air underground typically to naturally occurring aquifers, solution-mined salt caverns, and constructed rock caverns. Subsequently, the air is released and heated using a small amount of natural gas. The heated air flows through a turbine generator to produce electricity	Two commercial-scale facilities; third approved. For a typical development, total costs, including equipment, installation and grid connectivity, are estimated to be US\$2.0-2.5mn per MW; low operational costs near 0.7¢/kWh.
Flow batteries	Three systems that work to store and release energy through a reversible electrochemical reaction between two electrolytes: (1) cell stacks, (2) electrolyte tanks, and a (3) control system. In most flow batteries, two electrolytes flow from the separate holding tanks to the cell stack where a reaction occurs in one electrolyte and an oxidation reaction occurs in the other. Within the cell stack, liquid electrolytes flow past solid electrodes that are separated by an ion exchange membrane, which allows one of the charged species to move back and forth between the two electrodes (one direction of movement corresponds to discharge and the other to charging). After the reaction, the spent electrolytes are returned to the holding tanks; during recharging the process is reversed.	Four types are currently commercial: (1) Vanadium redox batteries; (2) Zinc bromine batteries; (3) Polysulfide bromide batteries; (4) Cerium zinc
Lead-acid batteries	LAs can be two standard types: flooded and valve regulated. Flooded batteries are found in cars and serve industrial uses as a deep charge battery. The younger valve regulated (VRLA) technology was developed to be longer lasting than the flooded technology and serve in industrial tool applications and as a source of backup power.	Widely deployed. Low cost makes it an attractive technology in the storage space, its price does not reflect the full cost of ownership that includes loss of battery life.

Overview of grid storage technologies

Technology	Overview	Deployment & cost
Sodium batteries	Employ sodium (Na) at the negative electrode (cathode), sulphur at the positive electrode (anode), and beta alumina as a solid electrolyte. During the discharge phase, molten metallic sodium acts as the anode, separated by a beta alumina cylinder from a sulphur container made from an inert metal acting as the cathode. The sulphur is absorbed in a carbon sponge. Alumina is a good conductor of Na ions but a bad conductor of electrons, avoiding self discharge. When Na gives off an electron, the Na+ ion migrates to the sulphur container. The electron travels through the molten Na to the contact and through the electric load to the sulphur container.	Because NaS batteries operate at high temperatures typically greater than 300°C, systems are only suitable for large-scale, stationary applications.
Lithium-ion batteries	Use chemical reactions between primary elements of a battery cell to create a flow of electrons. The battery discharges when lithium ions carry electric current from the cell's anode to its cathode through a non-aqueous electrolyte. An external electrical power source capable of applying a higher voltage than that produced by the battery forces the process to reverse itself during charging.	High energy-to-weight ratio and significant energy density makes them compatible with many applications, from consumer electronics to EVs. Round-trip efficiency of 80-90% and are durable up to 1,200 cycles.
Flywheel energy storage	Store energy in the form of the kinetic energy of a spinning mass. A flywheel is basically a spinning disc with a hole in the middle to be used for rotation. Flywheels generally consist of three parts: (1) rotor, a mass that can be rotated to store energy, (2) bearing system, the mechanism that supports the rotating mass, and (3) motor/generator. Energy is stored in proportion to the speed at which the wheel spins, which can require a small but persistent input of energy to the motor. Energy is extracted by reversing this process and using the motor as a generator, which in turn decreases the speed of the motor.	Depending on material composition related to bearing system choice, flywheels have applications for uninterruptible power supply, transportation, grid ancillary services, and bulk energy storage. Low lifetime cost of ownership due to easier maintenance and high reliability make the technology attractive as a source of backup and uninterrupted power to data centres.
Ultra-capacitors	Capacitors draw their name from the energy property that allows them to hold their charge, called capacitance (the ratio of the magnitude of the charge on two oppositely charged plates at either end of a cell to the voltage between the plates). The closer the two plates are to one another, the greater the capacitance. Ultra-capacitors are distinguished from standard capacitors by the enormous surface area of plates relative to the distance between them.	Low energy density but high power density and a cycle life above 10,000. Traditional application is power assist capacity, although newer functions include consumer electronics, automotive power assistance, and industrial applications.
Thermal energy storage	Use a building's cooling system to make cold water during off-peak cooling hours and then use it to provide cooling load support during peak hours.	Well-established storage technology that is typically deployed on a building-level scale to reduce peak-cooling loads for C&I firms.

Source: BofA Merrill Lynch Global Research

There might be winning technologies within a particular segment, but we do not see a single storage technology that is likely to dominate grid storage.

Table 95: Technological issues with storage technologies

Issue	Overview
Discharge time and system power	Typically, shorter discharge times and lower system power ratings meet power quality and reliability demands. Technologies with greater system power and longer discharge time enable bridging power to support applications such as renewable integration and T&D asset deferral – and enable energy arbitrage opportunities.
Power rating	The difference between energy and power is the difference between time of charge and discharge (energy is measured in kWh) and rate of charge and discharge (power is measured in kW or MW). For some technologies, the relationship between the two is fixed. In order to deploy batteries to discharge lots of power over a long time, they must be strung together in great quantity. For other technologies like the flywheel, however, the relationship between power and energy can be manipulated by altering the materials and design of the conversion component (ie, a motor for the flywheel).
Ability to charge/ discharge repeatedly	The cycle life of a battery deteriorates to a greater degree during deep discharges than does that of a flywheel.
Ownership cost	In addition to upfront capital cost, ownership cost refers to operational economics and lifespan. Materials and system design are chief determinants of ownership cost, which can be broken down among costs that scale with storage capacity, conversion, and balance of systems. Balancing upfront and lifetime costs is important.
Ways energy can be harnessed	Fossil fuels like NG and crude oil release energy through the excitement of chemical bonds, pumped hydro releases energy by means of gravitational energy, batteries release energy electrochemically through the separation of ions, and flywheels rely on the inertia of a rotating mass that unleashes kinetic energy. Each of these approaches exhibits varying energy density and power properties as well as dispatch capability and mobility. Pumped hydro and compressed air energy storage offer significant energy density but require specific geographic characteristics, where transmission needs to be brought in. Batteries, flywheels, and capacitors are not nearly as energy dense but are more modular and have exceptionally quick response time.

Source: BofA Merrill Lynch Global Research

Li-ion to be the spearhead

For newer technologies to be economic, storage projects need to serve multiple applications, have a long life, meet strict reliability standards, and have lower capital costs. According to Pike Research, over the next seven years, advances in materials science and manufacturing – which deliver higher energy densities, using lower cost materials, producing systems that will last at least twice as long as commercially available battery products – can reduce costs and drive sharp increases in the installed capacity of advanced batteries for grid-scale applications from a few hundred megawatts (MW) in 2013 to more than 10,000MW in 2020. Lithium-ion battery technology is the most promising as battery makers can leverage the technology and manufacturing developments of automotive storage:

- Li-ion batteries have round-trip efficiency of 80-90% and are durable up to 1,200 cycles.
- Their high energy-to-weight ratio and significant energy density makes Li-ion batteries compatible with many applications, from consumer electronics to electric vehicles.
- In adequate temperature ranges, they also have low self-discharge rates.
- There are questions surrounding safety and battery shelf life.

The market for energy storage on the grid, starting from a very low base in 2012, will surpass US\$30bn in annual value by 2022 and the total capacity of ESG systems worldwide will reach almost 56,000 megawatts by 2022 as per Pike Research estimates.

Ascribing value to non-generating assets

Greater adoption of energy storage technologies would require increased regulatory support. Monetization of efficiency gains, transition from simplified rate structures, and premiums for dispatchability are areas where regulation can have an impact on the economic viability of storage projects. Based on our discussions with industry executives, the most important task for regulators is to define the value of storage.

Transport - rail, bus, shipping & lightweighting

Table 96: BofAML Transport – Rail, Bus & Shipping & Lightweighting Stock List

Company	EE exposure
BOMBARDIER INC	High
CANADIAN NATIONAL RA.	High
CHINA RAILWAY GROUP	High
CSR CORPORATION	High
CSX CORPORATION	High
FIRSTGROUP PLC	High
GO-AHEAD GROUP PLC	High
GUANGSHEN RAILWAY	High
HEXCEL	High
NATIONAL EXPRESS GR.	High
NORFOLK SOUTHERN	High
STAGECOACH GROUP	High
UNION PACIFIC CORP	High
VOSSLOH	High
ZHUZHOU CSR	High
ALSTOM SA	Medium
CHINA RAILWAY CONSTR.	High
YANGZJIANG SHIP.	Low
BOMBARDIER INC	High
CANADIAN NATIONAL RA.	High
CHINA RAILWAY GROUP	High
CSR CORPORATION	High
FIRSTGROUP PLC	High
GO-AHEAD GROUP PLC	High
TORAY INDS.	Low

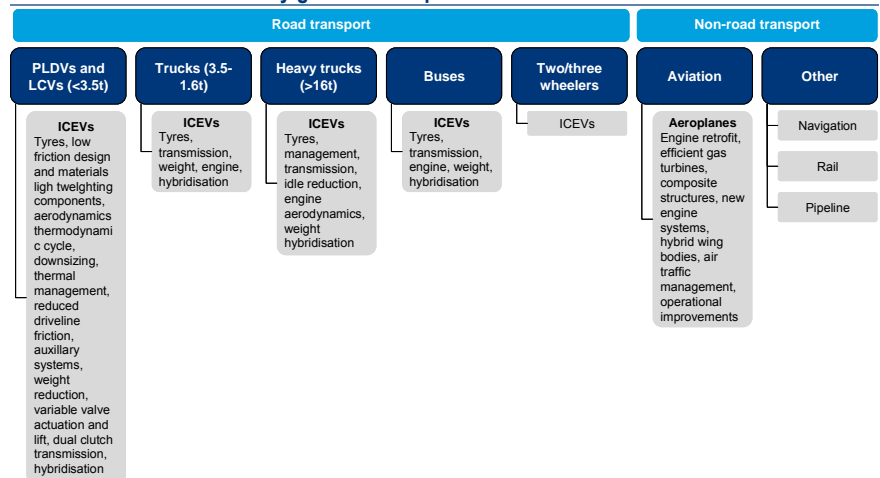
Source: BofA Merrill Lynch Global Research. * EE exposure = BofAML estimates of current sales derived from energy efficiency products, services, technologies and solutions

The transport sector accounts for more than 50% of world consumption of liquid fuels, and this share is forecast to increase to over 60% by 2035 (Source: International Union of Railways). It also accounts for 23% of global emissions – i.e., 6.5bn tonnes of CO2 – or the equivalent of 1t of CO2 per inhabitant of the planet. The carbon footprint of transport is linked to the fact that almost 20% of the world’s total delivered energy is used in the sector, where liquid fuels are the dominant source (i.e., gasoline, diesel and LPG on roads, kerosene in the air, and fuel oil for shipping). With oil substitution not a reality in the near term, this means growing pressure in terms of fuel costs and energy efficiency.

The long-term environment for rail, bus and coach, shipping – and lightweighting for air and road transport – is the most positive it has been in years. High fuel and labour prices, energy security concerns, rising household bills, urbanisation, congestion, environmental concerns and deregulation are all leading to greater investments and utilisation of rail and bus in particular. They are seen as solution providers, transporting more people further and faster, with lower emissions and congestion impacts. While changing mobility behaviour will be key to realising the efficiency opportunity, rail is set for strong growth, including via the switch from truck to rail in the US. The accessible rail market is set to register a 2.7% to 2.8% CAGR to reach €124bn by 2015-16E (Source: Bombardier, UNIFE). MENA and Latin America are seeing the fastest growth (Source: UNIFE). Bus and coach is also growing at a compound annual rate of 5-6.2% and should become a US\$61.5bn market by 2016E (Source: Fredonia). Finally, new environmental regulations from the IMO should see efficiency emerge as a major opportunity in the shipping sector.

We believe that a number of stocks are well placed to benefit from the theme of energy efficiency in rail, bus and shipping via their involvement in areas such as lightweighting, locomotives, passenger rail operators, rail services, railway signalling and control systems, rail transport for freight, public bus and coach operators, rolling stock and fuel efficient shipbuilders.

Chart 208: Potential efficiency gains in transport

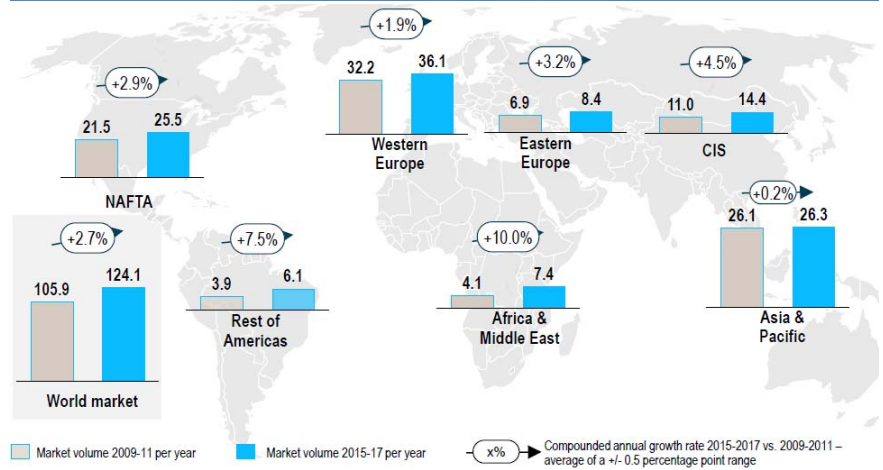


Source: IEA WEO outlook 2012, BofA Merrill Lynch Global research

Rail, €124bn accessible market by 2015-16

The accessible rail market is estimated to be worth €124.1bn worldwide in 2015-17 (vs. €105.9bn in 2009-11), with services and rail control markets the two fastest-growing segments (Source UNIFE).

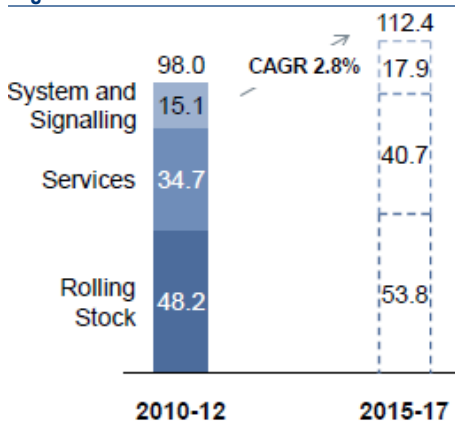
Table 97: Accessible rail market volume by region (€bn pa)



Source: UNIFE

U.S. public transit ridership, and public transport in general, is growing faster than car mileage (Source: American Public Transport Association).

Chart 209: Annual accessible market by segment



Source: Bombardier based on UNIFE 2012 Study

Stable, steady 2.7-2.8% growth to 2017

The world's rail market is stable despite the current economic downturn. Rail supply markets are forecast to grow at 2.7-2.8% in the next four years (Source: UNIFE, Bombardier).

Fastest growers - services & controls

Services and rail control markets are expected to show the strongest five-year growth rates (3.5-3.0% and 3.0-3.5% respectively), while infrastructure and rolling stock are growing at a slightly slower 2.0-2.5% (Source: UNIFE):

- **Rail control** is showing high growth rates driven by the rollout of ERTMS and PTC in the train protection segment towards the middle of the decade.
- **Services** are seeing high growth rates driven by a continuously expanding installed base and gradually increasing accessibility of several countries.
- **Infrastructure** is showing steady growth rates driven by large investment projects in Africa and Middle East as well as in Latin America.
- **Rolling stock** is seeing overcompensation of notable decreases in the Chinese VHS segment through investments in urban rolling stock, especially in metros (Source: UNIFE).

Table 98: Portfolio of rail products & services

	Rolling stock	Services	Systems & Solutions	
	Locomotives & equipment		Systems	Rail control solutions
Passengers	Locomotives	Fleet management	Automated people movers	Integrated control systems
Metros	Bogies	Spare parts	Advanced rapid transit	Onboard computer systems
Commuter trains	Traction converters	Logistics management	Light rapid transit	Automatic train protection & operation

Table 98: Portfolio of rail products & services

Rolling stock		Services	Systems & Solutions	
Passengers	Locomotives & equipment		Systems	Rail control solutions
Regional trains	Auxiliary converters	Vehicle refurbishment & overhaul	Automated monorail	Wayside interlocking & equipment
Intercity trains	Drives/traction motors	Component repair & overhaul	eMobility solutions	
High-speed trains	Train control & communication	Technical support	Operations & maintenance	
Very high-speed trains			Transit security	

Source: Bombardier

Highest growth in MENA & LatAm

In the near term, the market is becoming more fragmented and open to competition. Traditionally closed or non-railway markets are opening their doors, product demand is changing, moving away from a “high-tech” focus to quality at a reasonable price and there is a growing focus on safety, notably after the July 2011 HSR accident in Wenzhou China. The fastest growth regions to 2017 will be Africa & Middle East and Latin America – with the markets enlarged significantly in countries with so far small rail systems (‘Source: UNIFE).

Table 99: Accessible rail markets by region and CAGR 2015-2017 (vs. 2009-11)

Market	Mkt volume	CAGR					Key developments
		Overall	Control	Infrastructure	Services	Rolling stock	
Western Europe	€32bn	1.5-2.0%	1.5-2.0%	-0.5-0.0%	2.5-3.0%	2.5-3.0%	Steady growth driven by the rolling stock and the services segments: -Rolling stock main growth driver, with UK & France investing heavily -Infrastructure showing lowest growth rates, also carried by nationwide investments in the UK and France -Projects include VHS lines in France (e.g. bypass Nimes – Montpellier) and capacity improvements around London (e.g. transversals projects) -ERTMS progressing slower than anticipated, roll-out later this decade Markets stagnate after large VHS investments in China completed -Large Chinese VHS demands fulfilled up until 2009 and thus not maintained in subsequent periods – recovery in the long term -India investing heavily with plans of building a metro or a monorail system in cities of >-3m inhabitants (Bhopal, Jaipur, Kanpur, Lucknow, Pune, etc.) -Infrastructure growth expected, carried by projects in India, Indonesia, South Korea, Taiwan and Thailand
Asia-Pacific	€26bn	0.0-0.5%	3.0-3.5%	3.0-3.5%	2.0-2.5%	-2.5—2.0%	Annual growth of up to 5% pa driven by rail control and services: -Russia to invest significantly in electric locomotives and trams/light rail (replacement and extensions in various cities) in medium to long run -Accessible market for infrastructure stable - with decreases in Kazakhstan and particularly Ukraine mostly compensated by increases in Russia -Services showing a high growth rate because of growing installed base in last years and increased accessibility (spin-off of maintenance from RZD) Expected to become a major growth driver for the rail industry in the upcoming years -Very high expected growth rates even after accounting for delays/cancellations of projects -Projects include Doha and Dubai metro systems, the Saudi Land Bridge project, Mecca Mass Transit and the Mecca-Medina VHS line -Promising growth rates in other countries such as South Africa, Egypt in mainline and urban -VHS demand mainly stemming from smaller markets (e.g. Morocco) -Driven by the economic success Brazil, Latin America is expected to become a growth driver for the industry: -Brazil with plans of doubling its freight rail network to support the growing economy
CIS	€11bn	4.5-5.0%	7.0-7.5%	-0.5-0.0%	6.5-7.0%	4.0-4.5%	
MENA	€4.1bn	10.0-10.5%	2.0-2.5%	9.5-10.0%	18.0-18.5%	6.5-7.0%	
Latin America	€3.9bn	7.0-7.5%	5.0-5.5%	5.0-5.5%	4.5-5.0%	9.5-10.0%	

Table 99: Accessible rail markets by region and CAGR 2015-2017 (vs. 2009-11)

Market	Mkt volume	Key developments
		<ul style="list-style-type: none"> -Plans for solutions in urban transport in Brazil drafted, proposed and partially approved -Projects include extensions of Sao Paulo and Rio de Janeiro metro, Metro/light rail in Belo Horizonte, Brasilia, Cuiabá, etc. -Argentina planning replacements of large portions of its existing rail network – Santiago de Chile metro entailing large investment

Source: UNIFE

China & high-speed railway, bumpy road ahead

High-speed railway is listed as a key development area of high-end equipment. In our opinion, growth of China's railway construction may have peaked given the high base, but locomotives, railcars and parts have more room to grow given the lag in capex and export potential.

Exhibit 5: China's high speed railways



Source: BofA Merrill Lynch Global Research

Infrastructure investment peaked

Partly prompted by the need for economic stimulus during the global financial crisis, the Chinese government has approved many mega high-speed railway projects since 2009. Most of these have already commenced construction, and are scheduled for completion from 2011 to 2014.

China has budgeted spending on railway construction at 400bn yuan (US\$63.2bn) in 2012, a cut of about 15% vs. 2011. Rail construction spending was estimated at 469bn yuan in 2011 and 709bn yuan in 2010. We believe that the growth rate is set to decelerate sharply, although total investment may continue to rise moderately for a short while. As a result, we suggest investors focus on equipment and service suppliers rather than contractors for future growth potential. We think Rmb400bn is a conservative target set by new MOR minister and see some upside if the economy falters.

Rail reform plan unveiled: regulation & operation separated

In February 2013, the State Council announced during the congress meeting the separation of the railway regulatory and operational functions of MOR in the new railway reform plan. MOR will no longer exist; the State Railway Administration will assume regulatory functions, affiliated to MOT the China Railway Corporation will take over operational functions.

[China Industrials, 11 March 2013](#)

[China Industrials, 11 March 2013](#)

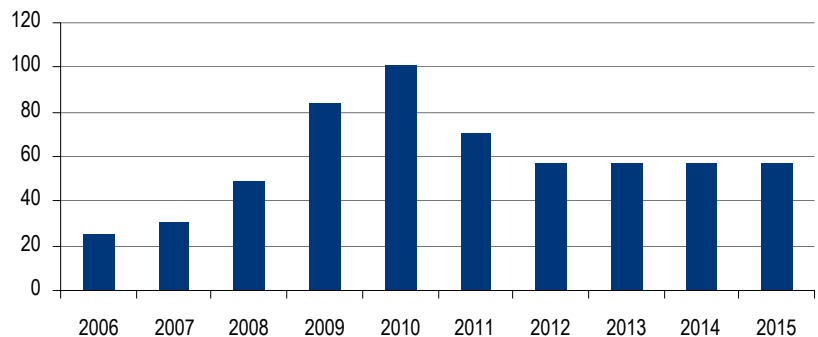
Implications of reform

Railway operators would be key beneficiaries as a result of potential change in tariffs for both cargo and passenger. Railway constructors will not be impacted immediately by MOR reform. However, in the medium/long term, constructors have to deal with increasingly rational capex, followed by better pricing as a result of the improved pricing mechanism. Railway equipment makers will likely see a resumption in delayed new orders awarded after the railway reform plan is unveiled. Over time, railway operators have to consider their profitability and demand outlook before placing big orders.

Long-term positive but short-term negative

We believe that the railway reform will have a positive impact on railway development in the longer run – by making investment and operation more efficient, with functions well defined and performed, in the same framework of greater transportation. Railway transportation should be greatly encouraged in an increasingly polluted and energy-dependent country. However, the road will likely be somewhat bumpy which may create confusion in the short term, in our view, taking into account the complexity of the reform and the already changed competitive landscape. In the long run, we expect order visibility, pricing transparency and payment to be improved as a result of more clarity in the regulatory regime and independence in investment decision (a gradual switch from purely planning to market based). However, rational investment would result in sustainable but unexciting orders.

Chart 210: Investment of MOR in railway sector – new infrastructure, modernization and rolling stock (€bn)



Source: SCl Verkehr GmbH, Constant exchange rate 1 CNY = 0.12 EUR for all years

Efficiency needs to be balanced with safety

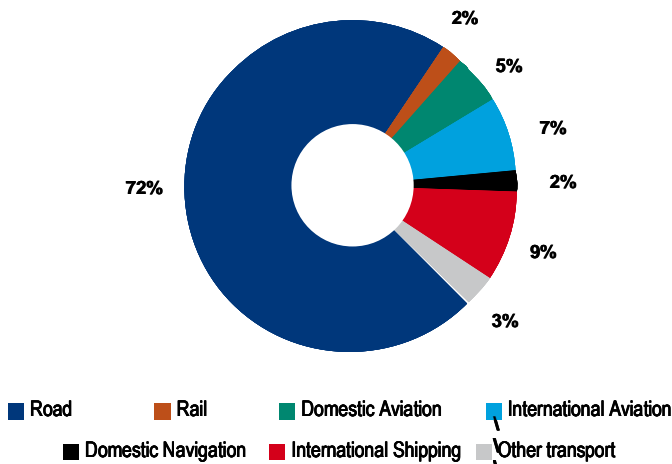
The HSR crash in the eastern province of China in July 2011 highlighted the need to balance efficiency with safety concerns, with design flaws, equipment failure and poor management all being cited as explanations for the crash. In addition to a reduced budget, the government has placed a greater focus on safety with the Ministry of Railways telling local units to slow down HSR by up to 50kph, to complete emergency response plans, recall faulty equipment, and improve work-safety training.

Rail is the most environmentally friendly form of transport

Rail transport should see sustained medium to long-term growth on the back of its environmental credentials. Rail is the most energy-efficient method of moving passengers or freight on land and only accounts for c.2% of emissions generated by the transport sector:

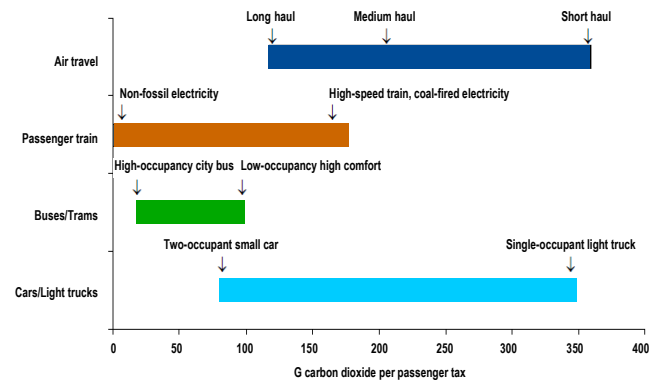
- Rail is on average 2-5x more energy efficient than road, shipping and aviation
- Rail is on average 3-10x less CO2 intensive than road or air transport
- With 7-10% of market share, rail still contributes less than 2% of the EU transport sector's CO2 emissions
- Through approaches including eco-driving, use of new rolling stock, light weighting, regenerative braking, optimisation of load factors, driver training and operational measures, railways are looking to improve energy efficiency by 30-50% by 2030 in Europe, for instance.

Chart 211: Transport CO2 emissions



Source: UIC

Chart 212: CO2 intensity of passenger transport

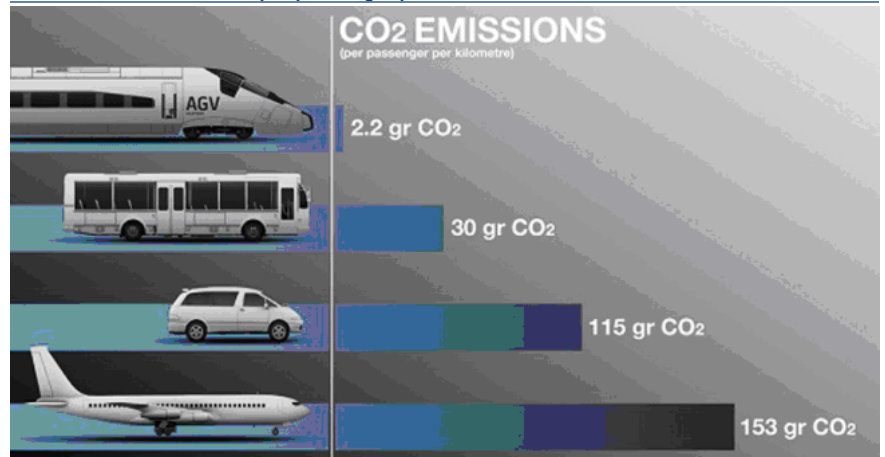


Source: UN IPCC

HSR beats all other forms of public transport

HSR – depending on the underlying energy source – has the potential to be the most environmentally benign form of public transport. For example, Alstom's AGV consumes the equivalent of only 0.4 litres of fuel per 100 km, or three times less than a bus (1.2 litre per 100 km), eight times less than a car (2-3 litres per 100 km), and fifteen times less than a plane (5-7 litres per 100 km).

Chart 213: CO2 emissions per passenger per km*



Source: Alstom. * AGV = Automotrice Grande Vitesse

Cross Reference

[Airlines - China, 02 June 2011](#)

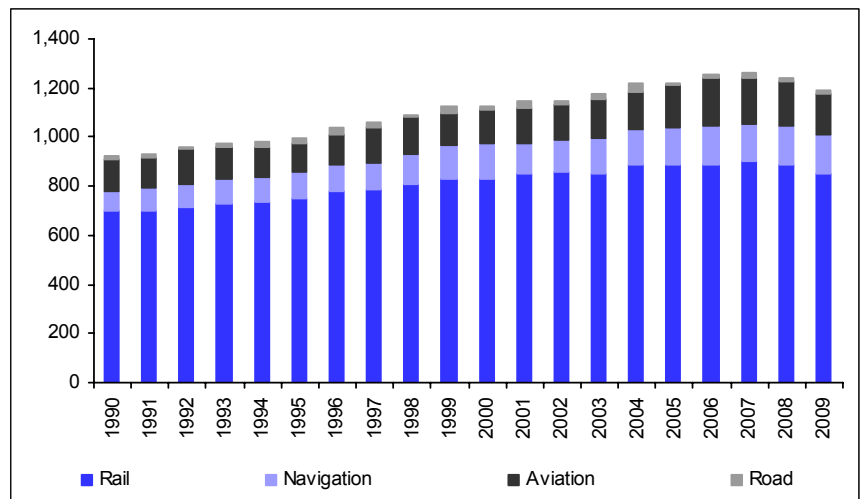
Demand inflexion point for rail vs. air is 800-1,000km

As rail gains increasing traction globally, it is important to understand the inflexion point which can influence a consumer's choice to take a train rather than a plane. Drawing on conclusions from a review of Japan's market south of Tokyo – one of the most dynamic passenger rail markets – the key inflexion point in demand between air transport and railways is on rail routes of between 800km to 1,000km (roughly 600-800km by air).

- **Train wins below 800km:** Rail dominates travel patterns on routes below 800km. However, the Japan-Osaka route still sees 18% of passengers fly despite a distance of only 553km. For Okayama (733km) the market share for air travel rises to 33% despite relatively infrequent flights.
- **800km-1000km - rail and air are equally matched:** The big drop in rail usage starts from the Tokyo-Hiroshima route (894km) where almost half (42%) of passengers travelling between the two cities go by air.
- **Air travel clearly preferred for rail routes longer than 1,000km:** On the Tokyo-Fukuoka route (1,175km), which takes almost five hours, air travel dominates with a 90% market share.

Another example of the above illustration is evident from the new high speed line in Spain between Madrid and Seville (c.400km), which increased its market share from 19% to 53% (source UIC).

Chart 214: Transport sector CO2 emissions by mode, 1990-2009 (m tCO2)



Source: IEA

Long-term trends are favourable

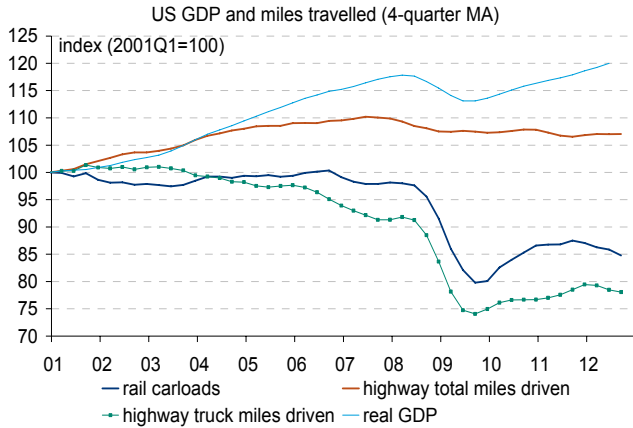
Rail should see sustained long-term growth on the back of some of the following sustainability trends, which we expect to spur the development of both rail and rail equipment:

- **US switching from truck to rail:** A drop in long haul trucking activity since 2000 has been exacerbated by a switch to rail, due to high fuel and labour costs as well as structural changes in the US economy. Since trucking volumes peaked in 2000, tonne mile activity in large trucks has declined by 23%, most severely during the 2008/09 recession

Cross Reference

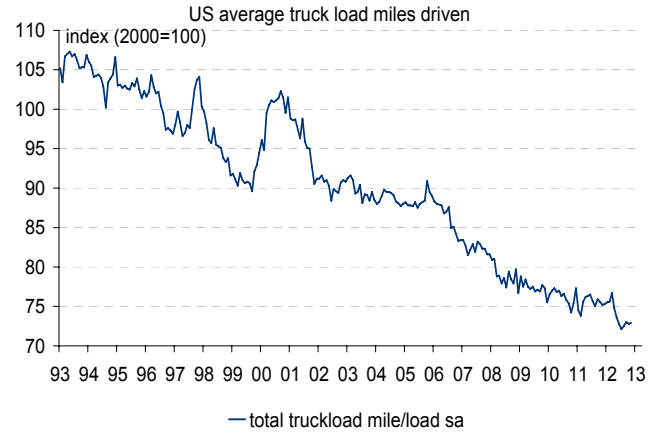
[Global Energy Paper, 18 February 2013](#)

Chart 215: The drop in long haul trucking activity since 2000 has been exacerbated by a switch to rail



Source: Bloomberg, BofA Merrill Lynch Global Commodity Research

Chart 216: Miles per truck load have declined on structural substitution for more than two decades now



Source: Bloomberg, BofA Merrill Lynch Global Commodity Research

The global urban population is set to grow from 3.5bn today to 4.6bn by 2025 (Source: UN)

- **Favourable regulatory frameworks:** Rail will be essential to realising long-term transportation targets, such as the European Commission’s goals of a 60% reduction of GHG emissions from the transport sector by 2050 (vs. a 1990 baseline), achieving CO2-free city logistics in major urban centres by 2030, and optimizing infrastructure utilisation and interoperability across borders.
- **Emerging market urbanisation:** Emerging markets need new railway infrastructures to support economic growth. They also host a large number of fast-growing cities (>1 million inhabitants) that have limited or no installed transit systems (e.g., in China). The transportation needs of these new urban hubs are translating into increasing demand for first implementation of turnkey transit systems.
- **Globalisation and interoperability:** Increasing global trade of goods is creating demand for railway transport systems for raw materials (USA, China, Russia, India, Australia, etc.). Interoperability requirements, such as the development of the ERTMS standard are also spurring growth in Europe and elsewhere.
- **Replacement of ageing rail equipment:** The ageing infrastructure and the increased traffic density on networks will require modernisation and upgrade efforts in the years to come. For example, 65 metro systems were built before 1980 and 23 before 1950 – with the busiest ones being among the oldest (i.e., London, NYC, Paris).
- **Increasing focus on safety,** reliability and efficiency will mean growing investments in signalling systems, the most efficient way to enhance the safety and capacity of the lines
- **Traffic congestion costs:** Traffic delays from road and air congestion mean huge wasted costs in terms of lost fuel and productivity. Estimates of the costs of congestion range from US\$119bn/year and 3.9 billion gallons of wasted fuel in the US (Source: Texas Transportation Institute) to £22bn/year in the UK by 2025 (Source: UK government).

Doubling the use of bus and coach transport in Europe alone would:

- reduce CO2 emissions by 50Mt/year+
- reduce road fatalities by 3k+/y
- reduce car traffic by 10-15%
- create 4m new jobs

(Source: Bus & Coach Smartmove)

Bus & coach, part of the solution

Buses and coaches offer an important solution to a range of mobility challenges including climate change, road safety, connectivity, social inclusion and congestion, among others. Rising gas prices - and rising usage in densely populated corridors on the back of low-cost fares and improving services (i.e. free Wi-Fi and curbside pick up) are playing an important role in an increasing number of consumers looking to bus and coach for inter-city transport.

World demand to rise 5% annually through 2016

The world market for buses is projected to climb 5.0% annually to 631,000 units in 2016E. Product sales will expand at an even faster pace in dollar terms, rising 6.2% per year through 2016E to US\$61.5bn due to increases in average bus prices. (Source: Freedonia Group Inc). Demand will be spurred by investments in public infrastructure development, an upturn in bus spending in France, Japan, and the US, and efforts to reduce pollution globally. The Asia/Pacific region is forecast to register the strongest market advances through 2016E fuelled by robust economic growth and expansion of urban transit systems in China and India particularly (Source: Freedonia).

Table 100: World Bus Demand (thousand units)

Item	2006	2011	2016	2006-2011 CAGR	2011-2016 CAGR
World Bus Demand	416	495	632	3.5	5
North America	57	38	48.8	-7.8	5.1
Western Europe	34.6	31.3	35.4	-2	2.5
Asia/Pacific	241.5	320.5	428	5.8	6
Central & South America	31.1	48.1	47.5	9.1	-0.3
Eastern Europe	22.1	23.5	27.6	1.2	3.3
Africa/Modest	29.7	33.7	44.7	2.5	5.8

Source: Freedonia

Table 101: Public transport passenger trips

City	Trips
New York	3.2bn
Chicago	0.52bn
Los Angeles	0.48bn
Washington	0.44bn
Boston	0.37bn

Source: 2009 Public Transportation Fact Book

Favourable growth drivers

In addition to the environmental advantages over other forms of travel described below – and government strategies to reduce emissions from surface transport – bus and coach has a number of favourable long-term growth drivers:

- **Changing U.S. consumer attitudes** Coach has become the fastest growing form of long-distance transport in the U.S. with inter-city bus travel growing by 7.1% in 2011, compared with 1.5% for air and 1.16% for rail (Source: DePaul University).
- **Policy and regulatory push:** As governments look to strike a balance between competitive transport systems that fuel economic growth and employment, and environmental and energy security concerns, more opportunities will arise for an increase in the modal share of bus and coach. The recession and focus on energy prices have made bus and coach an increasingly attractive option with the American Recovery and Reinvestment Act (2009) providing up to US\$6bn for bus purchases and Canada investing up to one-quarter of its transit infrastructure budget on bus transport.

Average passenger car occupancy rates are falling across the world. In the EU, in some cases the rate is as low as 1.1-1.2 in short distance commuting. Even for family trips, these range between 1.4 and 1.7 (Source: Bus & Coach Smartmove)

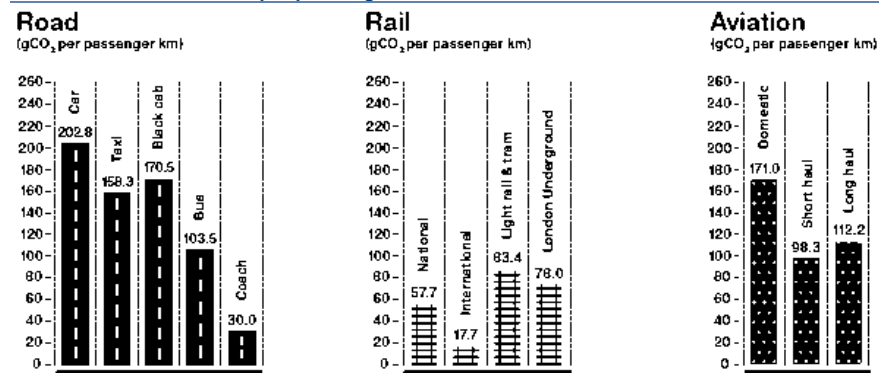
- **Emerging market economies:** The general economic expansion and urbanisation taking place in emerging markets is requiring workers to travel further, usually by bus, to reach jobs. China, for instance, has become both the largest market for buses and the largest producer, and is expected to be one of the fastest growing bus markets going forward.
- **Fighting congestion:** Buses and coaches are an asset in reducing congestion and, as a result, air pollution and road accidents. In Europe, one coach can replace up to 30 cars in terms of average occupancy rates, while one full coach has the potential to remove 55 cars from the road in the US. This is resulting in a greater focus on policy measures such as priority lanes and other such schemes.
- **Environmental concerns are increasingly driving customer behaviour** according to research by bus and coach companies. Closer cooperation with customers and local governments will be key to market buses as a green alternative to car use.
- **Establishment of dedicated and sometimes guided “busways”** in key cities across Australia, Europe and Central and South America.

Among the most environmentally friendly modes of travel

Buses, like trains, produce significantly less carbon emissions per passenger than the car – and are the most environmentally friendly form of road transport. According to Bus & Coach Smartmove – a multi-stakeholder initiative – bus and coach has significant advantages over rail, car and air:

- **Up to 10x more fuel efficient** to carry one passenger over 100km, buses and coaches need, on average, between 0.6 and 0.9 litres of diesel fuel whereas, on average, a diesel car will consume 5.9l of fuel, a gas-powered car 7.6l, an airplane 6.6l, and high-speed trains 2.6l.
- **Up to 4-6x lower CO2 emissions:** UK data show that coaches emit 0.03 kg of CO2 per passenger-kilometre. This is half that of trains and radically smaller than the amount emitted by cars (0.11) and airplanes (0.18).

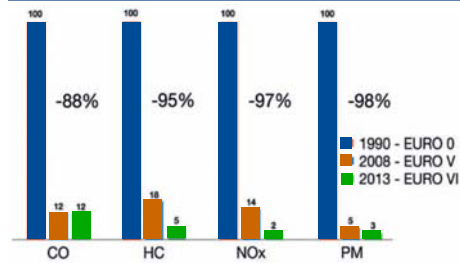
Chart 217: CO2 emissions per passenger km: road vs. rail vs. aviation



Source: Stagecoach

- **Lowest external costs:** the external costs (related to noise, accidents, congestion and pollution) of buses and coaches are 26% lower than those of trains. This includes the externalities resulting from building, maintenance and land coverage of the necessary infrastructure, as well as particulates emitted by roll resistance and braking.

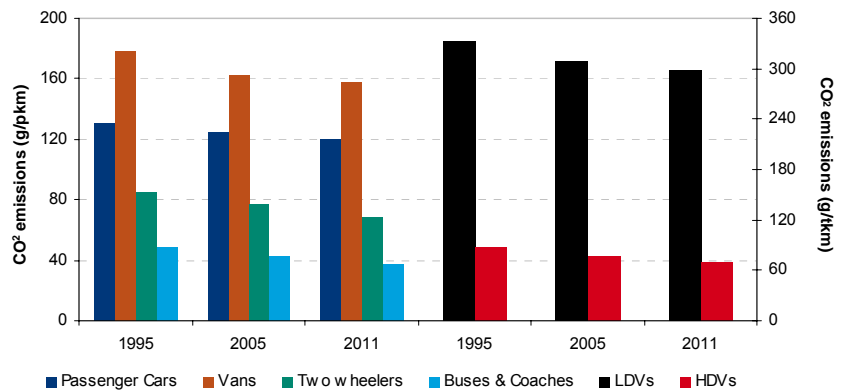
Chart 218: Noxious emissions reduction for heavy commercial vehicles



Source: European Commission

- **Ongoing environmental improvements** as manufacturers and operators renew 10% of the bus and coach fleet every year in many countries, using the latest available environmental technologies. This has resulted in significant improvements in noxious emissions reduction for heavy commercial vehicles, including buses and coaches. Emissions such as carbon monoxide, hydrocarbons, nitrogen oxides and other particles have been reduced by up to 98% in Europe over the past 20 years – and we are seeing increasing use of ultra low sulphur diesel fuel. Changes to driver behaviour are also helping to lower fuel consumption.

Chart 219: Specific CO2 emissions from road passenger and freight transport in Europe [redo ML style]

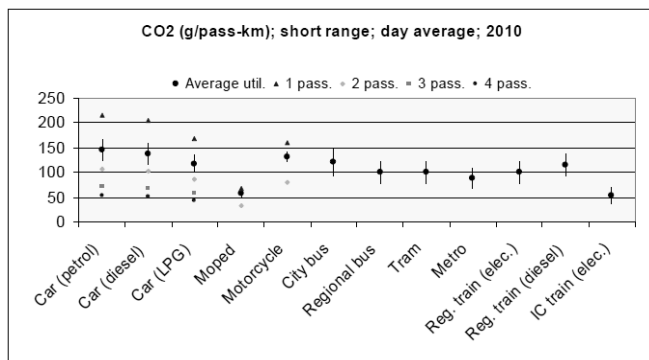


Source: European Environment Agency

Occupancy rates are key

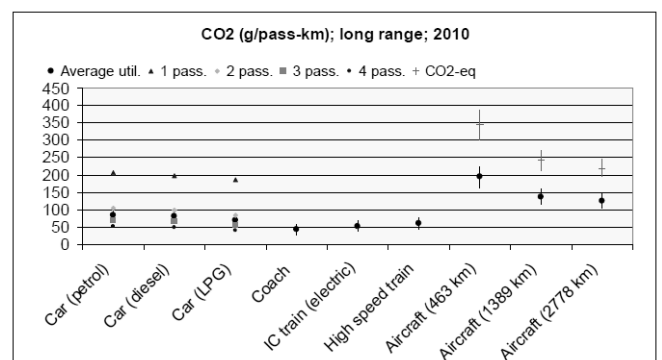
We note that for buses and coaches – as well as for other forms of transport – environmental performance is sensitive to the occupancy rate. Public transport buses with low occupancy rates almost perform at the same level as cars, while buses with high occupancy rates have a much better relative environmental performance.

Chart 220: gCO2 per passenger km – short range



Source: STREAM, CE (2008)

Chart 221: gCO2 per passenger km – long range

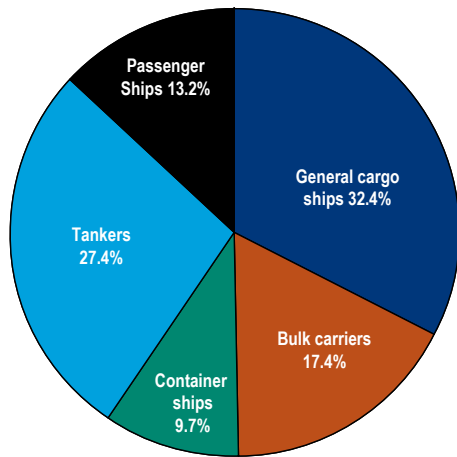


Source: STREAM, CE (2008)

Shipping, an emerging opportunity

Roughly 50,000 ships carry 90% of the world's trade cargo every year – with cargo ships being anywhere from three to thirty-five times more efficient from a gCO₂/t-km perspective than trucks or air freight, respectively. However, ships are responsible for a growing level of CO₂ emissions – and we anticipate that regulators will be looking to act in the coming years, as seen by the IMO's recent game changing decision on energy efficiency. Regulation, along with fuel costs, should push companies to seek efficient solutions thus creating new energy efficiency opportunities for the 50,000+ ships in the global fleet.

Chart 222: Total number of ships in world fleet



Source: International Chamber of Shipping

CO₂ emissions could triple by 2050

Ships are responsible for approximately 2.7% of global carbon emissions – with the extensive use of heavily polluting bunker fuel oil a major factor. China and the US were the largest CO₂ emitters at around 6Gt – followed by Russia, India and Japan (source: OCEANA). The global CO₂ figure could double or even triple by mid-century if no action is taken.

High fuel costs putting focus on efficiency

In terms of energy consumption, shipping also compares very favourably with other transport modes. However, the high oil price has meant that fuel costs now account for up to 50% of operating costs in some sectors and trades. Ship owners therefore have a strong incentive to reduce their fuel consumption, but the industry has also made efforts to increase fuel efficiency as a way of reducing shipping's environmental impact. Continuing developments in engine, hull and propeller design and the use of larger ships have been helping to deliver greater efficiencies in fuel oil consumption, with commensurate reductions in air pollution, CO₂ emissions and overall energy consumption.

US\$70bn wasted every year

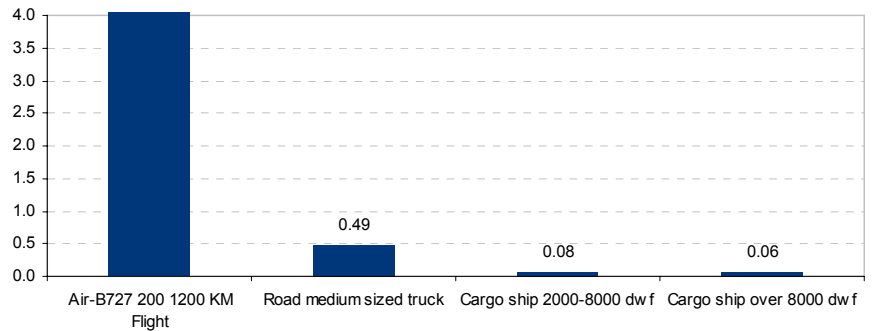
Shippers and charterers pay for around 70% of the approximate US\$250bn annual international shipping fuel bill directly (Source: ShippingEfficiency). The IMO has stated that there is a 25 to 75% latent efficiency locked within the shipping market. A 2010 report by shipping consultants claimed that as shippers/charterers paid for a significant proportion of bunker fuel that ship owners and operators were not incentivised to make their vessels more efficient – with US\$70bn of unrealised “profit” going to waste (Source: ShippingEfficiency).

15-20% improvements possible

The shipping industry consensus is that it may be possible to reduce CO₂ emitted per tonne of cargo transported one kilometre (tonne/km) by up to 15% to 20% to 2020, through a combination of technological and operational developments such as ship hydrodynamic and main engine optimisation, as well as the introduction of new and bigger ships.

IMO regulations to improve efficiency

Chart 223: Comparative fuel consumption



Source: International chamber of shipping, Swedish Network for Transport and the Environment

The UN International Maritime Organization (IMO) decided to regulate seafaring cargo and transport vessels to meet new energy efficiency and emissions guidelines. New regulations came into force on 1 January 2013. They make the Energy Efficiency Design Index (EEDI) mandatory for new ships and the Ship Energy Efficiency Management Plan (SEEMP) for all ships:

- **A system of energy efficiency design indexing (EEDI) for new ships**
The EEDI is a non-prescriptive, performance-based mechanism that leaves the choice of technologies to use in a specific ship design to the industry. As long as the required energy-efficiency level is attained, ship designers and builders would be free to use the most cost-efficient solutions for the ship to comply with the regulations.
- **A template for a Ship Energy Efficiency Management Plan (SEEMP) for use by all ships.** The SEEMP allows companies and ships to monitor and improve performance with regard to various factors that may contribute to CO₂ emissions. These include: improved voyage planning; speed management; weather routing; optimising engine power, use of rudders and propellers; hull maintenance and use of different fuel types. The SEEMP establishes a mechanism for operators to improve the energy efficiency of ships. Ships are required to keep on board a ship-specific Ship Energy Efficiency Management Plan (SEEMP) (Source: IMO).

Unlike in other sectors, this new set of rules will be applied equally to all UN countries regardless of whether they are industrialised or developing. The new rules will force all ships over 400 tonnes that are built after 2013 to improve their efficiency by 10% by 2020, then 20% by 2020 to 2024, and 30% after 2024. However, under regulation 19, the Administration may waive the requirements for new ships up to a maximum of four years (Source: IMO)

30Mt of CO₂ reductions by 2030

According to a study conducted by the IMO in November 2011 on the impact of mandatory energy efficiency measures for international shipping, by 2020 an average of 151.5Mt of annual CO₂ reductions can be achieved. By 2030 the CO₂ savings could increase to an average of 330Mt annually. Compared with Business as Usual (BAU), the average annual reductions in emissions and fuel consumed are estimated between 13% and 23% by 2020 and 2030, respectively (Source: Lloyds Register-DNV).

US\$200bn in fuel cost savings by 2030

The estimated reductions in CO2 emissions for combined EEDI and SEEMP, from the world fleet translate into a significant annual fuel cost saving of about US\$50bn in 2020 and US\$200bn by 2030, using fuel price increase scenarios that take into account the switch to low-sulphur fuel in 2020 (Source: Lloyds Register-DNV).

EU may also include shipping in the ETS

For several years the EU has been calling on the shipping industry to address rising greenhouse gases (GHGs). However, for the moment, it appears that the Commission is waiting to see what progress will be made with the IMO's efforts before it decides to incorporate shipping into the ETS, including the possibility of pulling in international shipping, much like it is planning to do with airlines. The European Commission has said that it is currently considering possible action in 2013 to introduce monitoring, reporting and verification of greenhouse gas emissions from maritime transport as a first step towards measures to reduce these emissions.

Link to Definitions

Industrials

Click [here](#) for definitions of commonly used terms.

Macro

Click [here](#) for definitions of commonly used terms.

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