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Green Investment Horizons: Effects of Policy on the Market for Building Energy Efficiency Technologies

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Executive Summary

This Working Paper:

- Informs the investment community by providing information and context on the potential market growth of energy-efficient technologies in buildings.
- Explores how different policies on energy efficiency and climate change may impact demand for energy efficiency technologies in buildings, within certain markets.
- Provides market growth forecasts based on two policy scenarios for the following technologies and markets:
    - Insulation in the European Union: to reduce energy use and loss;
    - Lighting worldwide: to develop new efficient lighting technology;
    - Building controls in the European Union and United States: to optimize the use of air-conditioning, and lighting appliances.

Energy used in commercial and residential buildings accounts for 40 percent of global energy consumption and approximately 24 percent of the world's greenhouse gases (GHGs). Heating, cooling, and lighting make up a large proportion of this energy use.

As governments around the world devise policies to reduce energy consumption and GHGs, and minimize dependence on foreign sources of energy, they are increasingly focusing on technologies that can improve the energy efficiency of buildings. Insulation, lighting, and building controls are the three energy efficiency technology categories that have emerged as having the most impact on improving energy use.

In recent years, policies aimed at improving energy efficiency in buildings in the European Union (EU), the United States (U.S.) and China, in particular, have gained momentum. This momentum has emerged from a convergence of initiatives designed to address climate change, improve energy efficiency, and reduce dependency on foreign energy sources. During the recent economic crisis, all of these jurisdictions have moved to stimulate technologies and markets related to energy efficiency as a way to complement other energy-related policies while boosting the overall economy. As these policies continue to play out, the prospects are good for significant market growth in these sectors.

Setting the Scene

This paper develops policy scenarios to forecast the market size of key energy efficient technologies for buildings over the next 20 years (2010-2030). The objective is to provide information and context for those planning to invest in business opportunities in these growing markets.

- The paper identifies the most important energy and climate change policies in three large markets – the European Union, the United States, and China.
- Within those markets, referred to as **"focus markets,"** the analysis concentrates on three key technologies – insulation, lighting, and building controls. (Refer to Annexes 2 to 4 to get quick facts on each of these technologies.)
- The potential future markets for these technologies are forecast based on specified assumptions about current and planned policies and market conditions.
- Forecasts are developed for two time frames: the short-term (2010-2020) and the long-term (2020-2030).
- The paper focuses primarily on buildings within the commercial and residential sectors.

Public policy actions to counter climate change and reduce greenhouse gas (GHG) emissions are increasingly focused on improving energy efficiency in buildings. This strong trend presents an opportunity for investors.

- **Emerging policies are likely to increase the uptake rate for energy efficient technologies.** Policies of varying stringency and scope have been introduced in the featured markets to save energy and reduce GHGs. For example, the European Union and China have mandated the phase-out of incandescent lamps within the next decade, while the United States has imposed lighting efficiency standards and will likely pursue phase-out as well. This creates a major market opportunity for more energy efficient compact fluorescent light bulbs (CFLs) and Light Emitting Diodes (LEDs) which consume 75 and 66 percent less energy than incandescent bulbs respectively.

- **The most common policy mechanisms use a combination of requirements and incentives.** For example, in the European Union, the Energy Performance of Buildings Directive (EPBD, 2010) sets a mandate encouraging member states to take measures to make all new buildings low or net-zero energy by 2020. Also, under the EPBD, an energy performance certificate must be displayed in all public and commercial buildings. This measure is designed to improve transparency between tenant and building owner on the energy efficiency of every building. In addition, the EPBD encourages member states to set up rebates, tax credits, and information on energy efficient technologies to help ease the burden of initial capital investment in building energy improvements. At present, the EPBD is primarily being interpreted as

a guidance tool by member states where it fits into their national priorities. Nevertheless, the Directive sends a clear signal endorsing active policies for improving energy efficiency of buildings.

Approach

Given the trends above, this paper constructs two plausible policy scenarios based on expectations of how specific focus markets may grow in the next 20 years as a result of newly introduced and planned legislation promoting energy efficiency in buildings. Data on CO_2 emissions, rate of technology uptake, and projected market growth of technologies were acquired from market research and annual company reports. These were used to project future developments of market sales and demand. The following policy scenarios were chosen based on the assumption that their implementation will have different impacts on market growth of insulation, lighting, and building controls. (Explanations of the methodology can be found in Section II and Annex 1.)

- **An "incremental" scenario** that focuses on the impact of current and planned policies.
- **An "aggressive" scenario** that assumes more ambitious public policy is enacted, further spurring technological advancements.

The main difference between the incremental and aggressive scenarios is that growth is expected to accelerate under the latter if existing policies become more stringent and if new policies help to reduce financing barriers. The differential between the two scenarios is clearer in the lighting and building controls sectors, where growth is expected to be slower in the short-term but accelerate in the long-term as technological innovation improves and products become more affordable.

Key Findings

The study findings suggest notable growth in market value[a], under both scenarios, across all three technologies from 2010-2030. Generally, growth in the short-term (2010-2020) in all three technologies in both scenarios is robust, suggesting a compelling investment opportunity. Although there is a slight decline in growth in the long-term (2020-2030), market size of the three technologies remains significant.

Forecast highlights under the "incremental" scenario.

Insulation (EU-15[b]): forecast to grow in the short-term with a compound average growth rate (CAGR) of 3.9 percent; and a 4 percent CAGR in the long-term.

- Short-term growth is expected to be driven by the Energy Performance Building Directive (EPBD 2010), which sets minimum building energy efficiency performance standards for existing buildings undergoing major renovations. In addition, a stronger commitment to reduce CO_2 emissions under the Kyoto Protocol may serve as a driving force to make buildings zero or low energy consuming.
- In the long-term, growth is projected to stay at modest levels since no new policies are introduced.

[a] Market value is defined as total sales.
[b] For insulation, data was only available for a subset of European Union members known as the EU-15. This group is made up of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom. All projections regarding insulation in this paper apply to this group of nations.

Lighting Markets (Global): forecast to grow at a CAGR of 6 percent in the short-term slowing to 5.7 percent CAGR in the long-term.

- In the short-term, the growth trend is expected to be attributed to an increase in popularity of fluorescent lamps, particularly CFLs in households. More efficient fluorescent and halogen lamps may dominate the lighting market through 2025.
- In the long-term, growth may slow without government intervention encouraging the uptake of energy efficient products or promoting research and development into advanced lighting technologies.

Building Controls (EU and U.S.): forecast to grow at a CAGR of 7 percent in the short-term and 6 percent in the long-term.

- In the short-term, growth is expected to be driven by increased government incentives for the installation of more sophisticated building controls in more buildings. This dynamic has the potential to attract new manufacturers of the technology into the sector and spur development of more affordable building control options.
- In the long-term, growth is expected to be driven by enforced energy consumption monitoring and disclosure throughout commercial and multi-unit residential buildings. Increased uptake of building controls technologies has the potential to attract new manufacturers into the sector.

Forecast highlights under the "aggressive" scenario.

Insulation (EU-15): forecast to thrive short-term, resulting in a CAGR of 8.4 percent, then decline sharply to 3.3 percent CAGR in the long-term.

- In the short-term, growth is expected to be driven by an extension of energy performance requirements for residential buildings under the EPBD (2010).
- In the long-term, growth will taper off if GHG reduction targets for buildings are achieved in the early stages of policy implementation.

Lighting Markets (Global): forecast to grow substantially at 8 percent CAGR then decrease to 6 percent CAGR in the long-term.

- In the short-term, growth is expected to be driven by countries that pledge to phase out energy inefficient lighting and switch to energy efficient alternatives over the next decade.
- In the long-term, growth will likely continue as incandescent and fluorescent markets shift production/market focus to LED technology.

Building Controls (EU and U.S.): forecast to grow rapidly at 10 percent CAGR in the short-term but slow to 7 percent CAGR in the long-term.

- In the short-term, growth will be determined by government programs that continue to subsidize the cost of new building control technologies and set specific regulatory standards for the installation of equipment to connect to smart grids.
- In the long-term, regulations that require monitoring and reporting of building energy performance are likely to continue to lead to an increase in control applications.

FIGURE 1: Actual (2005) and forecast market growth (2010-2030): Incremental Scenario

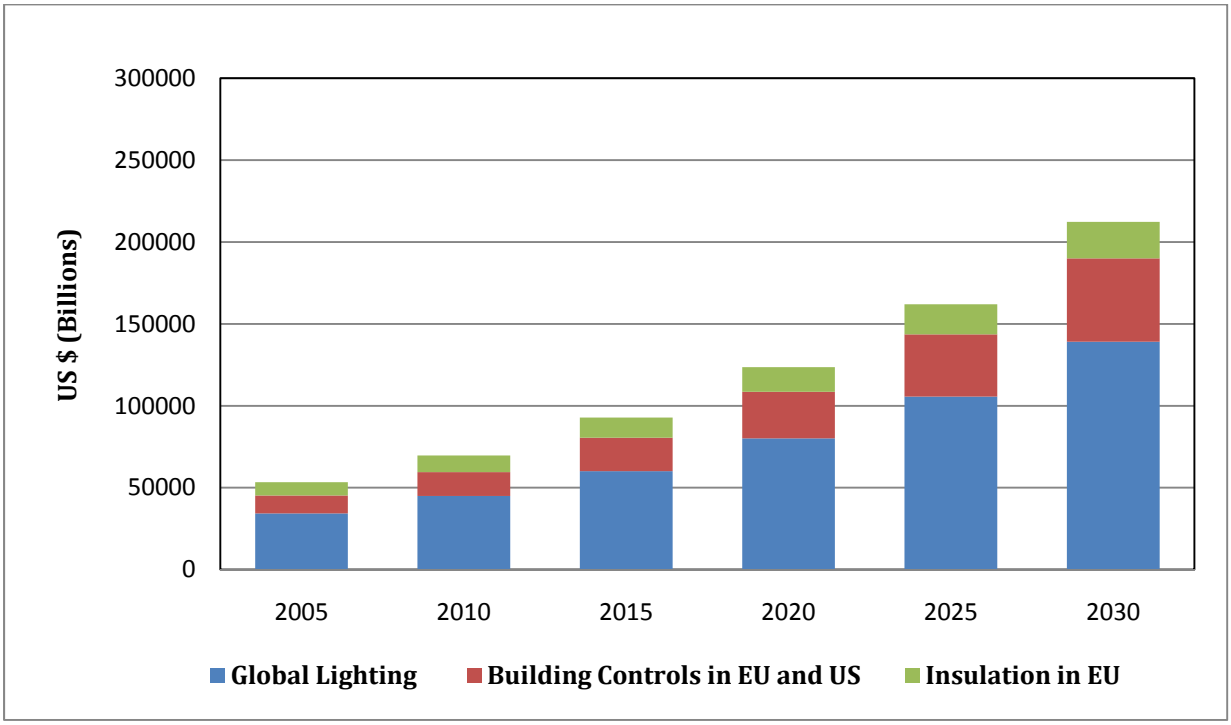
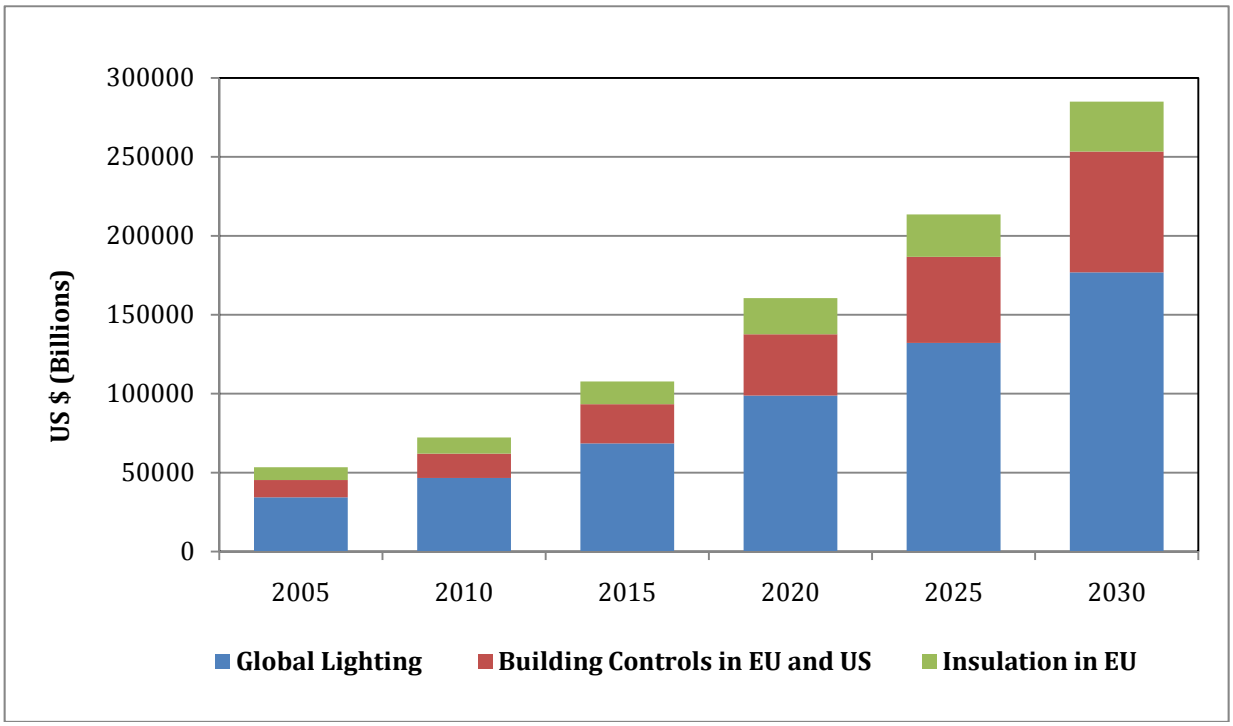


FIGURE 2: Actual (2005) and forecast market growth (2010-2030): Aggressive Scenario



I. Focus Markets and Key Technologies

Key Points

- **Recent energy-efficiency policies aim to promote investment by improving the pay-back period of new technologies through tax breaks, rebates, and low interest loans.**

- **Supportive policy environments can help to address critical financial barriers that hinder technological innovation relating to energy efficiency.**

1. Focus Markets

The European Union, United States, and China have been very active in recent years in using policy to influence overall energy consumption and GHG emissions. Policy initiatives addressing climate change, improving energy efficiency, and reducing dependency on foreign energy sources have been the main driving forces. In addition, policies such as the American Recovery and Reinvestment Act (2009) triggered by the global economic downturn, have made new funds available to promote or subsidize various energy efficiency projects in buildings, the impacts of which may continue for years to come. All these initiatives have provided market signals that have helped fuel growth in national or regional insulation, lighting, and building controls markets. In addition, state and local policies have played an important role in developing conditions for market expansion. In the United States and the European Union in particular, federal/regional policies on energy efficiency serve as guidelines and set minimum standards while giving U.S. states and EU member countries the freedom to implement a range of initiatives, incentives, and policy responses.

Green Investment Horizons focuses on these three markets--the EU, U.S., and China--because of the range of existing policies in place, and the likelihood that each of these jurisdictions will introduce additional energy efficiency measures in the coming years. From a policy perspective the European Union's 27 member nations (EU-27), the United States, and China also constitute the largest opportunity for improving building efficiency globally. The authors believe that these markets are the most aggressive and dynamic in promoting three key energy efficient building technologies:

- The insulation market in the EU with its large stock of under-insulated existing buildings;
- The lighting markets in the EU, the United States, and China because of the collective impact of new policy in these regions and because they represent a large proportion of the global market;
- Building control systems in the EU and the United States because these are the dominant markets for innovation and design of these technologies.

In addition to new efficiency mandates, these governments have also introduced supportive policies to help address critical financial barriers that hinder technological innovation relating to energy efficiency. Removing barriers that arise from the risks of economic downturn, a lack of information, “split incentives,” and behavioral inertia can help to (i) improve tangible cost savings, (ii) reduce pay-back periods, and (iii) create greater certainty over extended investment time horizons. (For summary information on these barriers, see Annex 5.)

Types of policy approaches emerging from the European Union, the United States, and China include:

- Deploying national stimulus spending and tax incentives to improve building efficiency;
- Establishing strict building codes and standards or energy performance requirements;
- Establishing GHG emission limits and guidelines;
- Providing tax credits, low interest loans, and rebate programs for installation of energy efficient technology;
- Improving availability and accessibility of information and communication on new energy efficient technologies.

Table 1 summarizes the main building-related energy efficiency and climate change policies presently enacted in the three featured markets.

TABLE 1: Major Energy Efficiency and Climate Change Policies in Focus Markets

European Union	United States	China
The Energy Performance of Buildings Directive (2010)[1] • First implemented in 2002 and recast in May 2010. • Requires all new buildings to be nearly zero energy buildings by 2020. By 2018, all public buildings shall be nearly zero energy buildings. • Requires member states to set intermediate targets by 2015 to achieve "zero- or low-energy" buildings. • Encourages a methodology to calculate building energy performance, mandates building certificate requirements and public display, inspection standards for heating and cooling equipment and air conditioning systems. • Requires member states to list incentives from technical assistance and subsidies to low-interest loans by mid-2011 for the transition to near zero-energy buildings.[2] **20/20/20 Climate Package (2008)** • Aims to cut greenhouse gases by 20 percent, generate 20 percent of energy from low-carbon or renewable resources, and improve energy efficiency	**American Reinvestment and Recovery Act (2009)[4]** • Makes available funds for improved weatherization of low income housing. • Increases funds for education and training of professionals in installing energy efficient retrofits. • Includes US $3.1 billion for state energy program funds. • Provides US $6 billion in loans for renewable energy systems. **The Energy Policy Act (2005)** • Mandates a 35 percent drop in energy use from 2005 by 2010 for all existing federal buildings. • Promotes energy efficient technological innovation through low interest loans and tax credits. • Provides tax incentives for insulation products that meet the International Energy Conservation Code.[5] • Supports the Building Energy Codes Program, which mandates energy efficient building codes.[6] **Energy Independence**	**11th Five Year Plan (2006-2010)** • Identifies building energy efficiency as a priority for energy efficiency improvement. • Sets a target of reducing energy consumption from lighting and HVAC in public buildings by 50 percent.[7] • Enables a joint strategic partnership with the United Nations Development Programme and the Global Environment Facility. Beginning in 2010, the plan is to phase out incandescent lighting, using a 'technology push/demand pull' strategy.[8]

European Union	United States	China
by 20 percent by 2020. **Energy Services Directive (2005)[3]** • Recast in 2009, the Directive requires member states to submit National Energy Efficiency Action Plans, to: • Reduce the amount of energy that is required to deliver energy services to EU citizens and businesses. • Establish indicative targets and action plans to reach a 9 percent reduction in energy consumption by 2016. • Promote the supply side of energy services and also create stronger incentives for the demand side. • Ensure that all energy end-users have access to energy audits, to help identify ways to save costs effectively. • Encourage (where financially and economically feasible) provision of billing information that includes energy consumption by source, use, and actual time of use.	**and Security Act (2007)** • Establishes a zero-energy commercial buildings initiative. A national goal is set to achieve zero-net-energy use for new commercial buildings built after 2025. • Sets an energy efficiency standard for general service incandescent lamps. • Authorizes the Energy Efficiency and Conservation Block Grant (EECBG) Program with a budget of over US $2.7 billion to assist energy efficiency and conservation strategies. • Requires that total energy use in federal buildings be reduced 30 percent from 2005 by 2015.	

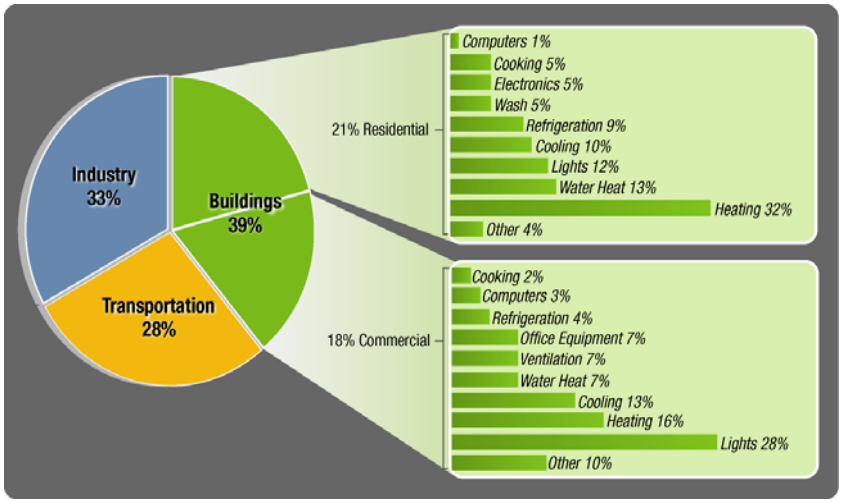
2. Key Technologies

Insulation, lighting, and building controls technologies were chosen for this paper because of their promising growth prospects and their efficacy in helping improve overall building energy efficiency.

One basic approach to reduce energy use in buildings is to improve the building "envelope" by reducing air exchange and heat loss through improved **insulation** of walls and roofs. Since lighting draws power and also adds to the heat load of a building, a second logical approach is to use artificial **lighting** more sparingly, and with more energy-efficient technology. The less energy a light uses, the less heat it puts into the building, and the lower the cooling costs. Thirdly, especially in commercial and large multi-residential buildings, more advanced **building control systems** such as temperature and heating, ventilation, and air-conditioning (HVAC) control, allow for more effective management of energy throughout a building. Thus, many broad policy initiatives target these three aspects of energy use in buildings. (A quick overview of the three technologies is provided in Annexes 2 to 4.)

For illustrative purposes, Figure 3 gives a breakdown of energy demand in existing commercial and residential buildings in the United States. In residential buildings, lighting, heating, and cooling together account for approximately 54 percent of total energy demand, compared with 57 percent in commercial buildings.[c] To further emphasize the point, lighting, heating, and cooling consume approximately 55 percent of electricity use in buildings in the United States.[9]

FIGURE 3: U.S. Energy End-Use in Commercial and Residential Buildings



Source: Steve Selkowitz, Lawrence Berkeley National Lab, 2006

A. Insulation

This paper focuses on the insulation market in the EU because of the potential for expansion under the Energy Performance of Buildings Directive (EPBD, 2010). Installing insulation is easier in new buildings than in old because it does not involve tearing through existing walls. The efficiency of a building's envelope largely depends on air tightness, the level of insulation, and the thermal properties of the walls, windows, roof, and ground or basement floor. Types of materials used for insulation include glass wool, mineral wool, and several foam products.

[c] Commercial buildings include office buildings, retails, and warehouses. Residential buildings include single-family houses (including two-family houses and terraced houses), multi-family houses, and high-rise buildings.

TABLE 2: Major Policies Influencing EU Insulation Markets

Focus Markets	Regulatory Controls	Economic & Market Based	Fiscal Instruments & Incentives	Strategies & Targets
EU	**The Energy Performance of Buildings Directive (2010)**[10] • Requires all new buildings to be nearly zero energy buildings by 2020. By 2018, all public buildings shall be nearly zero energy buildings. • Requires member states to set intermediate targets by 2015 to achieve "zero- or low-energy" buildings.	**EU Emissions Trading Scheme (2003)** • Requires each Member State to prepare and publish a National Allocation Plan for emissions between 2008 and 2012. • Scheme currently targets energy efficiency in industry, and will include other sectors as future allocations of emission credits are reduced.	**EU Economic Recovery Plan (2009)** • Created a loan program to help with the initial costs of installing insulation.[11]	**20/20/20 Climate Package (2008)** • 20% primary energy savings commitment. **Energy Services Directive (2005)** • Establishes 1% final energy efficiency improvement above business as usual for a total of 9% final energy savings by 2016.

B. Lighting

In this paper the global market for efficient lighting is projected to grow substantially, due to the adoption of policies that phase out incandescent lights in the next five years.

Lamps are responsible for the release of 1,900 million tonnes (Mt) per year of CO_2. According to the International Energy Agency this is equivalent to about 70 percent of total CO_2 emissions from light passenger vehicles worldwide in 2008.[12] Government policies to phase out inefficient technologies combined with private sector leadership in developing cost-effective and energy efficient lighting will likely drive a shift toward new products. The analysis in this paper covers market forecasts for lamps using the following bulb technologies: incandescent, linear fluorescent (T8 and T5), compact fluorescent (CFLs), high-intensity discharge (HIDs), and light emitting diodes (LEDs). For several decades three multinational manufacturers have dominated the international lamp market--Phillips (Netherlands), General Electric (United States), and OSRAM (Germany).[13]

TABLE 3: Major Policies Influencing Global Lighting Markets

Focus Markets	Regulatory Controls	Economic & Market-Based	Fiscal Instruments & Incentives	Strategies & Targets
EU	**The Eco-Design Directive (2005)** • Recast in 2009 to set new minimum energy performance standards (MEPS) for energy using products. • Imposes progressive phase out of incandescent lighting by 2012.		**Economic Recovery Plan (2009)** • Created a loan program for energy efficient lighting technologies.	**EU 20/20/20 (2010)** • A commitment to reduce energy consumption by 20 percent by 2020. Will impact lighting markets, as lighting is a key component of energy use in buildings.
U.S.	**Energy Independence and Security Act (2007)** • Requires light bulbs to use 20 percent to 30 percent less energy than incandescent bulbs between 2012 and 2014. Department of Energy to set standards to reduce energy use to no more than 65 percent of current lamp use by 2020.		**American Recovery and Reinvestment Act (2009)** • Provides tax cuts and rebates for ENERGY STAR lighting products. **Energy Protection Act Sec 103 (2005)** • Provides grants to nonprofit institutions for installation of energy efficient lighting.	
China	**The Medium and Long-term Plan of Energy Conservation (2004)** • Covers the 2005-10 and the 2010-20 period. • Calls for replacement of ordinary incandescent lamps with high-efficiency CFLs and LEDs.	**Energy Saving Law, Product Quality Law and Standardization Law**[14] • Implements a CFL subsidy program. Currently there is a 30% to 50% national subsidy on CFL bulbs. The Beijing municipality provides an additional 40%.	**China stimulus** • Commits US$233 billion toward "green themes" such as energy efficiency. Some of these funds will be available for lighting upgrades.	**2020 Energy Efficiency** • Aims to reduce energy by 20% from 2005. Government buildings are the targets for energy saving initiatives, especially through lighting improvements.

C. Building controls

This paper focuses on building controls markets in the EU and the United States. The policy assumptions are based on an increase in government subsidy programs to support research and development of more user-friendly systems, and the promotion of smart meters in residential buildings. Building controls offer energy savings by optimizing the use of commercial heating, ventilation, and air conditioning (HVAC), lighting, and other appliances. Technologies employed include energy management control systems, occupancy sensors, photo sensor controls, demand controls, and smart meters. A relatively small number of manufacturers currently make up a large portion of the market. These are Honeywell and Johnson Controls (United States), Siemens (Germany), and Schneider Electric (France).

Table 4: Major Policies Influencing Building Controls in the European Union and United States

Focus Markets	Regulatory Controls	Economic & Market-Based	Fiscal Instruments & Incentives	Strategies & Targets
EU	**Energy Performance Building Directive (2010)** • Encourages guidelines on the types of building controls to be installed, to improve energy efficiency (e.g. time control for optimized energy use, stand-by loss reduction, capacitors, and transformers with low losses).	**EU Emissions Trading Scheme (2003)** • Encourages member states to create financial incentives.	**Energy Performance Building Directive** • Encourages member states to promote tax exemption for certain building controls products.	**EU 20/20/20** • Commits to reducing energy consumption by 20% by 2020. Building controls are one of the most cost-effective ways to achieve efficiency gains by integrating existing heating, lighting, and cooling systems.
U.S.	**EISA (2007)** • Aims to cut energy use in federal buildings by 30% by 2015; requires new and renovated federal buildings to reduce their reliance on fossil fuels; requires that new buildings consume 30% less energy than that stipulated by existing codes.		**Energy Conservation Block Grant (2007)** • Authorizes US$2 billion in grants to encourage energy efficiency and conservation in commercial, residential, and municipal buildings.	

II. Scenarios and Methodology for Forecasting Market Growth

Key Points

- **The incremental scenario focuses on likely outcomes from current and planned energy and climate change policies relating to energy efficiency in the building sector.**

- **Under the aggressive scenario, new policies and other supporting initiatives unleash entrepreneurial innovation including business models that spur greater investment and overcome traditional financial barriers.**

In order to analyze the growth potential of the three selected technologies in the focus markets, two scenarios--incremental and aggressive--were created based on differing policy outcomes.

The two scenarios reflect policies relating to climate change and energy introduced in the past five years and discussed in previous sections. They do not reflect other factors that could impact market growth or technological change, such as dramatic changes in energy prices, where significant increases could further expand the growth prospects of the featured technologies. The reader should also bear in mind the distinct differences between the three markets. By example, energy prices are much lower in the United States and China than in the EU, thus, price increases in these two countries are likely to have greater impacts on consumer behavior.

The scenarios were chosen to help differentiate the potential market impacts of the current policy regime as it plays its way through to implementation, including the potential impacts of more aggressive policies likely to emerge in the future to combat high energy consumption rates and related GHG emissions.

1. "Incremental Scenario"

The incremental scenario focuses on possible outcomes from current and planned public policies relating to energy efficiency in the building sector. "Planned" policies in this paper refer to legislation in the focus markets that has been passed but not yet implemented, as well as policies that are under debate or awaiting approval by executive bodies or legislatures. These policies are expected to promote market growth by setting clearer standards and guidelines for the three key technologies and by providing financial incentives to business and consumers.

Policy assumptions under the incremental scenario:

- **Stimulus spending--building efficiency is a central theme in governments' efforts in the EU, the United States, and China to counteract the global economic downturn through fiscal stimulus spending and tax incentives:**
    - Global stimulus spending relating to energy efficient buildings amounts to US$66.8 billion and includes measures such as building shell retrofits or weatherization, appliance rebate programs, and smart grid investment.[15]
    - The American Reinvestment and Recovery Act (ARRA, 2009) has allocated US$32 billion toward building energy efficiency and retrofits.[16]

- Although many of these stimulus measures were introduced in the past one to two years, the trickle down impact of the funding will play out for several years to come.

- **Energy efficiency and climate change policies in focus markets--energy efficiency as a strategic priority at the national and supra-national level provides a positive environment for the deployment of energy efficient-related technologies.** In addition to stimulus spending, other supporting policy mechanisms include national policies which have laid the foundations for:
  - Deployment of minimum building codes and standards or energy performance requirements throughout the EU and the United States;
  - Establishment of GHG emission limits and guidelines;
  - Provision of tax credits and rebate programs;
  - Improvement in the availability and accessibility of information on energy efficiency technologies.

- **Implementation of product standards relating to energy efficiency**--in the focus markets, energy efficient product standards mostly refer to household and commercial appliances, ranging from refrigerators to lighting fixtures. Currently, building codes are often poorly enforced, which inhibits the financial attractiveness of investments.[17]

TABLE 5: Summary of Product Standard Policies Driving Energy Efficiency

European Union	United States	China*
EU Energy Label (1992) • Rates energy efficiency of products from A (most efficient) to G (least efficient). • All light bulbs, cars, and most household electrical appliances carry the label. **Eco-design Directive for Energy-using Products (2005)** • Establishes energy performance requirements for products standards for lighting and HVAC. • Recast in 2009 to include Energy-Related Products (ErP) such as insulation. • Energy performance certificates are required for all new and existing buildings.	**Energy Independence and Security Act (2007)** • Addresses appliance energy efficiency standards and rebates for both commercial and residential buildings. • Requires general-service incandescent light bulbs manufactured after 2007 to reduce wattage by 28 percent by 2014, and 92 percent in 2020.[18] **Energy Star** • Over 60 product categories. • Includes only products performing in the top 25 percent of the market benchmarks.	**Minimum Energy Performance Standards (MEPS, 1989)** • Covers up to 22 residential and commercial appliances, including lighting, heating and cooling equipment. **Voluntary energy efficiency labeling (1998)** • Modeled after the U.S. Energy Star program. • Labels 50 products. • Requires annual audits of production facilities. **"Energy Label"** • Imposes a mandatory label on energy consumption of a range of products, such as refrigerators and air-conditioners. • Adapted from the EU Energy Label.

* All China information on product standards have been acquired from -- Nan Zhou, "Status of China's Energy Efficiency Standards and Labels for Appliances and International Collaboration," (2008), Ernest Orlando Lawrence Berkeley National Laboratory, available at http://china.lbl.gov/sites/china.lbl.gov/files/LBNL_251E._Status_of_Chinas_Energy_Efficiency_Standards_and_Lables._Mar2008.pdf (accessed on May 6, 2010).

2. "Aggressive Scenario"

Under the aggressive scenario, new policies and other supporting initiatives unleash entrepreneurial innovation including business models that spur greater investment and overcome traditional financial barriers. (The barriers to investment are summarized in Annex 5.) This scenario builds on the incremental scenario by accelerating the development and deployment of "disruptive" technologies, such as LEDs, as well as the introduction of more stringent national building GHG emissions targets and energy efficiency standards.

i. Policy assumptions under the aggressive scenario:

Governments will adopt more ambitious measures targeting deployment barriers and unlocking significant growth in building efficiency technologies in response to growing and alarming scientific evidence of climate change and energy insecurity. An example of these policy shifts includes: **Europe intensifying its commitment to energy efficiency and mandating a 40 percent improvement in energy efficiency by 2020.** The EPBD was created as a framework, imposing a few overarching targets but for the most part leaving impact dependent on how each member state interprets and implements the directive. However, the recasting of the EPBD in 2010, creating more financial incentives and requiring more accountability from Member States, could predicate overarching EU legislation that strictly enforces reduction targets and low end-use energy consumption.

- **In particular, the aggressive scenario assumes that policy developments in the United States and the EU will strengthen their commitment to energy efficiency**, mandating a 40 percent energy efficiency improvement by 2020. As a result, zero- or low-energy buildings would account for a large percentage of U.S. and European buildings by 2020.

- **Both the EU and the United States emphasize advanced building controls and smart metering programs.** To complement other policy measures, the EU and the United States accelerate smart metering and demand-response programs. Smart meters are installed in the vast majority of EU and U.S. homes and businesses by 2030. In addition, advanced building control technologies such as automation systems and central controls are applied to all public sector buildings in both markets.

- **U.S. legislation adopts an aggressive climate change bill that includes carbon cap-and-trade** and/or taxes that go beyond current regulation levels set by the Environmental Protection Agency. At the time of writing, the American Clean Energy and Security Act passed by the U.S. House of Representatives had set objectives that were not accepted or modified by the U.S. Senate, thus causing immediate prospects for U.S. climate legislation to fall through. However, the likelihood of comprehensive U.S. climate legislation in the next 5 to 10 years is considered high in this scenario.

ii. Technology assumptions under the aggressive scenario:

To meet the emission reductions targets called for by climate change scientists, several new technologies play an important role.

- **Widespread conversion of buildings in the EU to very low energy consumption and even zero net energy.** There is only a rough understanding today of what a zero-energy building would entail, and how large-scale deployment of such measures would impact the current energy supply system. What is clear, however, is that advances in building design, improved insulation, and solar heating will play an important role in moving toward these types of buildings, especially in retrofitting.

- **LEDs make up a large proportion of the market for general lighting services.** The aggressive scenario assumes that LEDs are cost competitive in 2015 and are integrated as incumbent technologies as incandescent lamps and linear fluorescent lamps naturally wear out. It also assumes that new types of fixtures will come to the market as a result of improved and cost-effective LED product availability.

3. Methodology: Estimates for Growth Forecasts

The market growth forecasts in this analysis were informed by private market research reports and by forecasts by technology sector companies. They were confirmed through interviews with specific industry experts familiar with sector growth prospects.[19] Market size estimates were not broken down by the impact of individual policies.[d]

Growth forecasts for the insulation market in the EU-15 were estimated by:

- Assuming that the insulation market is influenced primarily by CO_2 reduction goals set by the European Commission under the EPBD (2010) and the Kyoto Protocol.
- Incorporating CO_2 emissions forecasts into the underlying models, based upon the EPBD scenario from studies prepared by EURIMA[20] and Ecofys [21] to establish reduction goals for each assumption.
- Building upon growth forecasts for the insulation market from similar research conducted by the Freedonia Group.[22]

Growth forecasts for the global lighting market were estimated by:

- Assuming that the disruptive technology nature of LEDs will help to drive the market and that other countries will model their policies after the EU and China, to phase out incandescent lighting.
- Determining a base overall market value, from an informed estimate based on lighting market growth reports from Greentech Media,[23] Electronics Design Strategy News[24] and Freedonia.[25]
- Verifying the combined result against growth projections from manufacturers in the industry e.g. Philips[26] and the China Association of the Lighting Industry.[27]

[d] More detailed information about the methodology and assumptions in the underlying models for this analysis are available from the authors upon request.

Growth forecasts for the building controls market in the EU and the United States were estimated by:

- Assuming that technological innovation and increased government policies encourage the installation of building controls.
- Combining the total assets of the four largest building controls companies--Siemens,[28] Johnson Controls,[29] TAC/Schneider,[30] and Honeywell[31] to get an estimate of the overall base market value in 2008.
- Verifying market size estimates against studies from private market research--Building Services Research and Information Association (BSRIA) and BCC Research.[32]

4. Scenario Risks and Caveats

The following risks and caveats apply to the two policy scenarios described in this study:

- A sustained recessionary environment limiting the availability of capital could suppress investments in building efficiency, despite the countervailing force of stimulus spending in the sector. Building energy efficiency technologies are linked to construction markets, which in turn are closely tied to general economic cycles. Slower general growth in global construction markets in the near term could dampen growth prospects for the building technologies sector in general, slowing hotspot growth in the near to mid-term.

- Policies aimed at improving building efficiency cannot completely overcome investment barriers including unstable, distorted, or incomplete pricing patterns; information asymmetries; lifestyle and behavioral influences; and consumption patterns. Policy initiatives aim to overcome these barriers through innovative means, but have not yet been completely proven.

- The slowness and uncertainty of the policy-making process can hinder market growth despite timely initiatives promoting building energy efficiency over the past five years. Delays in expected policy initiatives could slow projected growth rates for both scenarios.

- While climate and energy policy and technological advances are significant and influential factors in promoting the growth of energy efficiency markets, additional factors were not considered in this analysis. As highlighted previously, significant changes in energy prices did not fall within the scope of this study. A major energy supply disruption, for example, could cause dramatic price increases, potentially resulting in faster growth rates.

III. Results: Sizing Tomorrow's Markets

Key Points:

- **Building controls and lighting markets are forecast to have the fastest growth rate in the short-term (2010-2020) under the incremental scenario; while insulation and building controls grow fastest under the aggressive scenario in the short-term.**

- **Growth in the lighting market is fast changing as a result of policies phasing out inefficient lighting. Higher efficiency LED sources are forecast to create a "disruptive technology" situation that stimulates markets for luminaire and standard lighting socket replacement on a massive scale.**

- **Growth in the building controls market is forecast to be driven by policies that promote technologies that help building owners and operators understand end-use contributions to whole building energy use.**

1. Key Findings

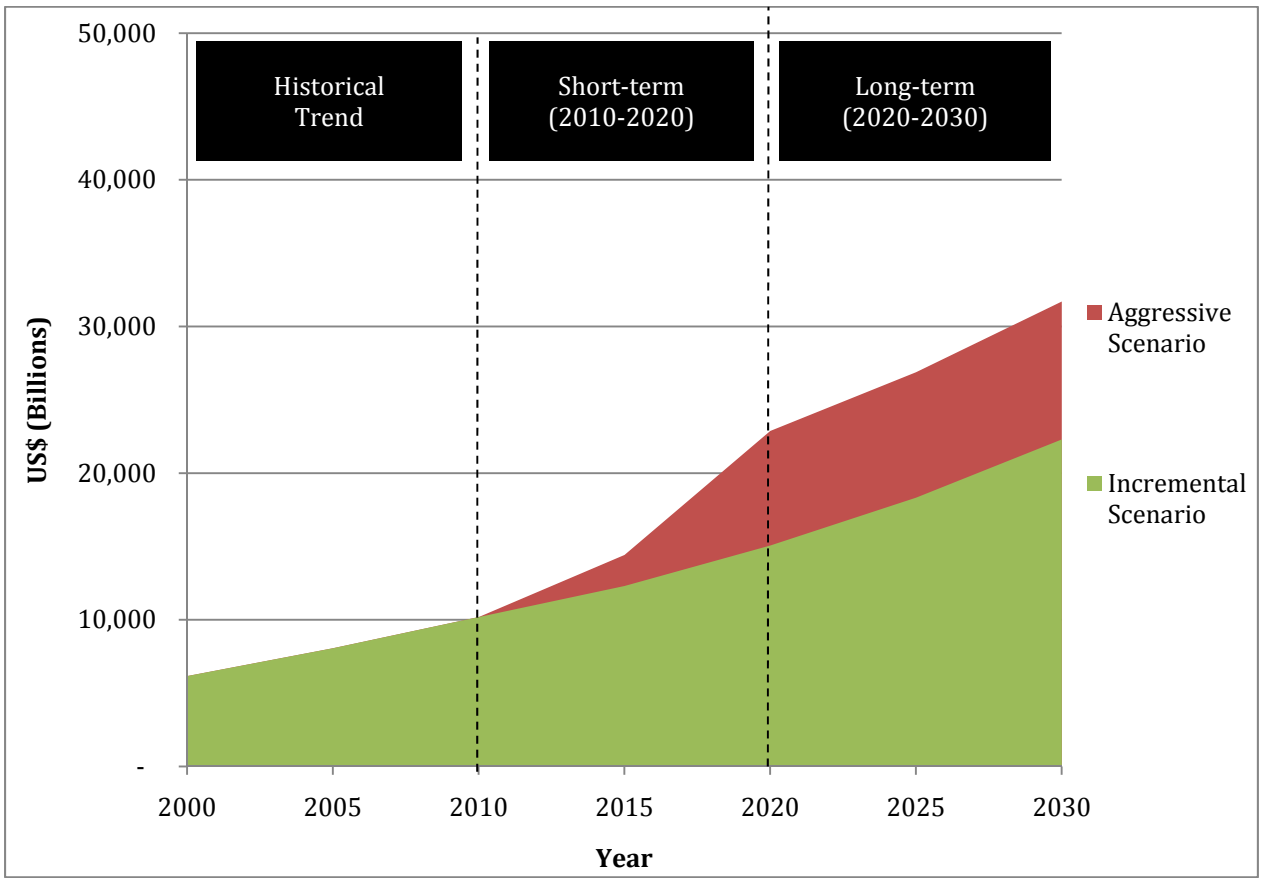
The findings of this paper suggest impressive growth in the markets for building energy efficiency under two different policy scenarios, which present opportunities for the discerning and forward-looking investor. Table 6 summarizes the forecasts for the three focus markets, before the forecasts for each technology are analyzed in greater detail.

TABLE 6: Summary of Potential Drivers and Outcomes for Market Growth Scenarios

Focus Markets	Time Frame	Incremental Scenario	Aggressive Scenario
Insulation: EU	Short-term (2010-2020)	• Increased number of government stimulus and subsidy programs. • A strengthened European Energy Performance Buildings Directive (EPBD) leads to increased insulation deployment.	• EPBD extended to all residential buildings. • EPBD implementation is expected to take three to four years; CO_2 reductions as a result of increased insulation installation begin in 2014.
		Market growth: 3.9% CAGR Estimated market value: US$15 billion.	Market growth: 8.4% CAGR Estimated market value: US$22 billion.
	Long-term (2020-2030)	• Growth is projected to stay flat since no new policies are introduced.	• EU continues to be committed to reducing CO_2 emissions, but growth slows down in insulation deployment.
		Market growth: 4% CAGR Estimated market value: US$22 billion.	Market grows: 3.3% CAGR Estimated market value: US$31 billion.
Lighting: Global	Short-term (2010-2020)	• High efficiency fluorescent lamps (including CFLs and Linear FL) capture a larger share of overall lighting energy consumption, compared to incandescent light bulbs.	• Lower priced LEDs capture new global lighting markets in commercial and residential applications, beginning a major transformation of the lighting industry. • Policies phasing out traditional incandescent lamps shift markets to LED based fixtures.
		Market growth: 6% CAGR Estimated market value: US$80 billion.	Market growth: 8% CAGR Estimated market value: US$139 billion.
	Long-term (2020-2030)	• More efficient fluorescent and halogen lamps dominate the lighting market through 2025.	• Comprehensive LED packages become the predominant technology
		Market growth: 5.7% CAGR Estimated market value: US$98 billion.	Market growth: 6% CAGR Estimated market value: US$176 billion.
Building Controls: EU and U.S.	Short-term (2010-2020)	• More focus from governments on building energy performance drives control systems into smaller buildings, with more sophisticated controls migrating down to residential applications.	• Aggressive investment through stimulus and subsidy programs and other regulatory initiatives moves comprehensive control packages and equipment into more buildings, with more connectivity to smart grids.
		Market growth: 7% CAGR Estimated market value: US$28 billion.	Market growth: 10% CAGR Estimated market value: US$38 billion.
	Long-term (2020-2030)	• Building dashboard applications grow with new connectivity for smart grid pricing functionality. New entrants open new expanded markets.	• EPBD expansion and policies in the U.S. drive monitoring of building energy performance. • Requirements to monitor and disclose energy performance lead to an increase in control applications.
		Market growth: 6% CAGR Estimated market value: US$51 billion.	Market growth: 7% CAGR Estimated market value: US$76 billion.

2. Sizing Tomorrow's Markets: Insulation in the European Union

FIGURE 4: Actual and Forecast EU Insulation Market Size, 2000-2030



Insulation market assumptions and forecasts under the incremental scenario:

Short-term:

- Efforts by the European Commission to strengthen the EPBD in 2010 lead to increased insulation deployment.
- Increased number of government stimulus and subsidy programs reduces the cost of insulation installation.
- Insulation market is influenced primarily by CO_2 reduction goals set by the European Commission.
- **In the short-term, from 2010-2020, the market grows at 3.9 percent CAGR reaching an estimated market value of US$15 billion**.

Long-term:

- In the long-term, growth is projected to stay low since no new policies are introduced.
- By 2020 significant insulation retrofit opportunities are achieved as a result of the Directive .
- **From 2020-2030, the market steadily grows at 4 percent CAGR reaching an estimated market value of US$22 billion**.

Insulation market assumptions and forecasts under the aggressive scenario:

Short-term:

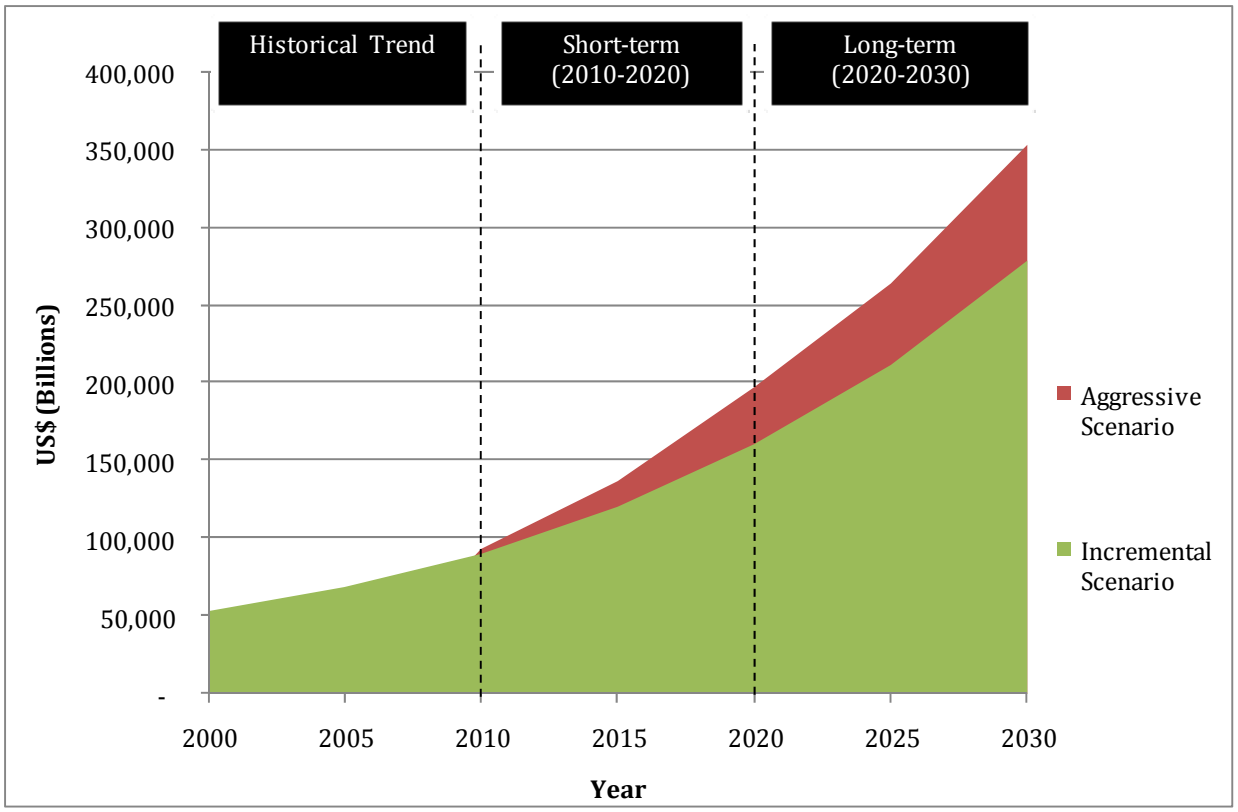
- The EU intensifies commitments to the Kyoto Protocol (2012) and EU-20-20-20 (2020) goals to reduce CO2 emissions by 20 percent
- Insulation is assumed to make up 42 percent of CO_2 emissions reductions under the EPBD.[33]
- **In the short-term, from 2010-2020, the market grows at 8.4 percent CAGR reaching an estimated market value of US$22 billion.**

Long-term:

- Increased size of insulation market is influenced primarily by CO_2 reduction policies, which include extending the Directive to all residential buildings.
- Implementation of the extended EPBD to all houses is expected to take three to four years and thus reductions begin in 2014.
- **From 2020-2030, the market grows steadily at 3.3 percent CAGR reaching an estimated market value of US$31 billion.**

3. Sizing Tomorrow's Markets: Global Lighting

FIGURE 5: Actual and Forecast Global Lighting Market Size, 2000-2030



Lighting market assumptions and forecasts under the incremental scenario:

Short-term:

- Traditional incandescent lighting is largely phased out by 2020 as a result of EU, United States, and Chinese policies, with CFLs and advanced, higher efficiency incandescent technology filling existing sockets.
- Fluorescent technology (including CFLs and linear fluorescent) continues to become more efficient, and captures a larger share of the overall lighting (energy consumption) market.
- LED lighting starts to make inroads in the marketplace from 2015 though uptake remains concentrated in niche markets, with the highest level of penetration in colored-light applications such as mobile appliances, traffic signals, exit signs, electric signage, and automotive applications.
- **From 2010-2020, the market grows at 6 percent CAGR reaching an estimated market value of US$80 billion.**

Long-term:

- More efficient fluorescent and halogen lamps continue to dominate the lighting market through 2025.
- Comprehensive LED packages become the predominant technology.
- **From 2020-2030, the market grows steadily at 5.7 percent CAGR reaching an estimated market value of US$139 billion.**

Lighting market assumptions and forecasts under the aggressive scenario:

Short-term:

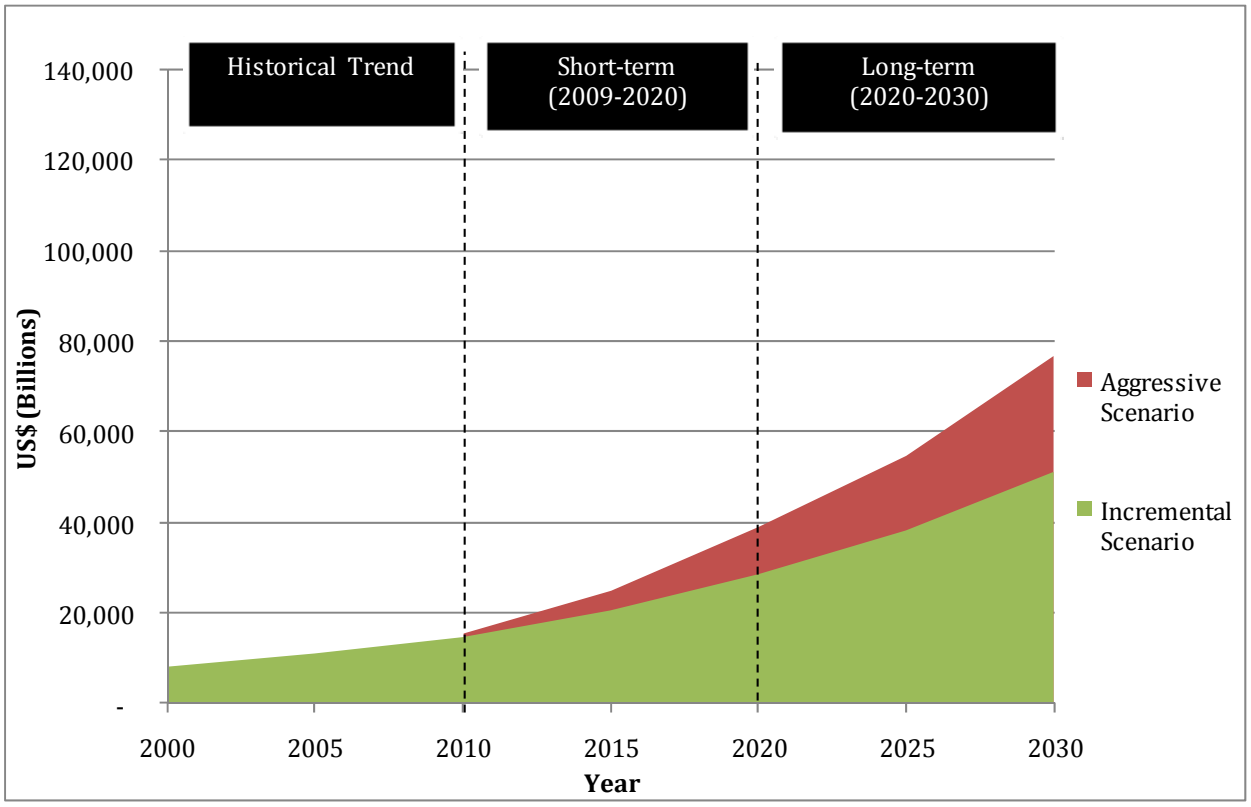
- LED lighting and other high efficiency sources drive increasing investment into new lighting equipment.
- New LED technology options accelerate the replacement of traditional incandescent and fluorescent lighting systems resulting in a substantial transformation to LED.
- **From 2010-2020, the market grows at 8 percent CAGR reaching an estimated market value of US$98 billion.**

Long-term:

- Higher efficiency, cost-effective LEDs create a “disruptive technology” situation which stimulates markets for luminaires/fittings and standard lighting socket replacement on a massive scale.
- **From 2020-2030, the transition to LED technologies results in 6 percent CAGR reaching an estimated market value of US$176 billion.**

4. Sizing Tomorrow's Markets: Building Controls in the European Union and the United States

FIGURE 6: Actual and Forecast Combined Building Controls Market Size, EU and United States, 2000-2030



Building controls market assumptions and forecasts under the incremental scenario:

Short-term:

- More focus from governments on building energy performance drives control systems into smaller buildings, with more sophisticated controls migrating down to residential applications.
- More sophisticated controls are installed, and better utilized in greater numbers of commercial buildings and applied in smaller buildings.
- Advanced control systems for buildings become information portals as more building systems are integrated and harmonized and traditional information technology companies enter the building controls market.
- New, sophisticated market entrants such as IBM and CISCO emerge from traditional IT industries, more closely integrating the currently separate control systems, while the historical building control firms expand the range of systems under integrated control.
- **In the short-term, from 2010-2020, the market grows at 7 percent CAGR to reach an estimated market value of US$28 billion.**

Long-term:

- Application of dispersed data centers increase as servers and advanced communication technology within buildings make enhanced control and integration with building system controls possible.
- Building dashboards gain dramatically higher market penetration as applications are developed for different markets, making it easier for building owners to understand and control energy use.
- **From 2020-2030, in the EU and the United States the market grows at 6 percent CAGR reaching an estimated market value of US$51 billion.**

Building controls market assumptions and forecasts under the aggressive scenario:

Short-term:

- New applications, such as smart grid and expanded enterprise infrastructure, where building controls are linked with telecommunications and other data systems within the building, create new opportunities for intelligent building controls.
- Greater focus on energy cost reduction, widely available smart metering, and policies driving reductions in energy use in residences and smaller buildings, ensures that advanced control systems and building dashboards gain dramatically higher market penetration.
- New entrants offer competitive, user friendly products that allow smaller energy consumers to better understand energy cost savings opportunities and the ramifications of their daily energy use/operational decisions.
- **From 2010-2020, the market expands to residential applications and multi-site connections. This drives a 10 percent CAGR and an estimated market value of US$38 billion by 2020.**

Long-term:

- EPBD expansion and policies such as mandatory energy performance disclosure in the United States drive monitoring of building energy performance.
- Requirements to monitor and disclose energy performance lead to an increase in control applications.
- **From 2020-2030, the market grows at 7 percent CAGR reaching an estimated market value of US$76 billion.**

IV: Summary and Reflections for the Future

Key Points:

- **Achieving major energy and greenhouse gas (GHG) emission reductions in buildings will require a continuing, transformative policy and behavioral shift in how energy is used in buildings.**

- **Investors should track policy developments closely as the energy and climate change agenda is likely to be fast changing in the European Union, the United States, and China.**

- **Transformative opportunities in insulation, lighting, and building controls technologies promise to open doors for new entrants and for the development of disruptive technologies.**

Policy makers are taking the lead in facilitating a transformative shift in how energy is used in buildings. As the political impetus to promote energy efficient technologies in buildings intensifies, investment opportunities will continue to grow. Future trends supporting the energy efficient building technologies market include new energy and climate change policies, tighter energy efficiency standards, and "green recovery" stimulus packages.

Based on the findings of this paper, the market growth for the three key technologies is promising against a supportive policy backdrop. The policy environment promises to drive expansion in the focus markets, especially in insulation and lighting. In building controls, while the technologies are available, the opportunities for improving affordability are yet to be explored by policy makers. In the long-term it is likely that the global lighting market will be the fastest growing, followed by the building controls market in the European Union and the United States and then the insulation market in the EU.

Investors should closely follow policy developments as the energy and climate change agenda is likely to be dynamic in the focus markets. In addition to the policies highlighted in this paper, other initiatives are likely to emerge. In the EU there will be a role for policies and incentives to improve building energy efficiency by encouraging retrofits in older buildings, which make up the largest percentage of the region's building stock. In the United States the potential for further policy intervention also exists as the newer building stock expands. The same trend is expected in China, which has one of the largest construction markets and growing consumer demand for green building products and designs. [34]

Transformative opportunities in lighting and building controls technologies promise to open doors for new entrants and for the development of disruptive technologies. In lighting, LEDs are considered "disruptive" as they enter the market and offer longer-lasting and more energy efficient alternatives. Most importantly the return on investment for LEDs is expected to be high, which is already making uptake of the technology easier and faster. In terms of building controls, the wide range of innovative intelligent technologies is driven by consumer demand to improve energy management and reduce costs. The increased focus on research and development into such technologies is creating an attractive market for new entrants.

In summary, this study finds a high likelihood of notable growth in market value, ranging from US$123 billion to US$283 billion under both scenarios, across all three technologies from 2010-2030. Generally, growth in the short-term (2010-2020), in all three technologies in both scenarios is robust, suggesting a compelling investment opportunity. Although there is a slight decline in growth in the long-term, market size of the three technologies remains significant. As world consciousness of the value of energy efficiency increases, and as prices and policies continue to evolve, these markets are likely to expand even further than the projections offered in this paper. The technologies studied here are among the most obvious candidates for growth--thus constituting "low-hanging fruit". The canny investor will also keep an eye out for disruptive technologies beyond those already expected to emerge in LEDs. New products offering a cleaner, safer, more efficient building environment are set to command an advantage in tomorrow's markets.

ANNEX 1: Key Assumptions and Methods

Assumptions and methods for calculating the market growth of insulation in the EU-15 include:

- Assuming that the insulation market is influenced primarily by carbon dioxide (CO_2) reduction goals set by the European Commission under the Energy Performance Building Directive (EPBD 2010) and the Kyoto Protocol.
- Basing CO_2 emissions forecasts on a scenario which projects the impacts of the EPBD (2002-2010 = -1.62% CAGR, 2010-2015 = -1.76%) to achieve the 40 percent reduction goals in the EU.[35]
- Basing growth forecasts for the insulation market of the EU-15 upon market projections by the Freedonia Group, which includes consideration of the impact of the EPBD (2008-2012 = 3.10%, CAGR, 2012-2017 = 4.34% CAGR).
- Focusing on the EU-15 because the model was built from studies conducted by EURIMA and Ecofys, which were created in 2002. When the EPBD was first implemented in this era, there were only 15 member states in the EU. Because of these data limitations, all market estimates for this sector refer to the EU-15, as noted early in the paper.
- Smoothing year-to-year expectations with CAGR forecasts. As a result, 2009 and 2010 market projections for the insulation market are higher than expected.

Assumptions and methods for calculating the market growth of global lighting include:

- The overall global building lighting market is assumed to be US$80 billion in 2008, based on private market research reports by Freedonia, Greentech Media, and others, and cross-referenced with reports from major lighting equipment manufacturers and trade associations. Of this market, some portions, such as decorative lighting fixtures, will not be affected by climate/energy policies, and much of the related equipment will track global construction markets.
- More efficient light sources--such as CFLs, other more efficient traditional technologies, and LEDs, along with necessary ballasts and the fixtures/fittings that are used to house the more efficient sources will grow more quickly during both the short and long term due to the policies noted. The portion of the lighting market that would be considered “efficient lighting” (and subject to more rapid growth from the referenced policies) is estimated to be half of the total market, or US$40 billion.
- Growth in both the incremental and aggressive scenarios during the short term is driven by incandescent lighting “phase-out” policies, which stimulate sales increases of higher value lighting products, particularly in the 2010 through 2015 period.
- Growth of efficient fixtures and related equipment in the short-term is assumed to be moderate (other than retrofit activity), driven by levels of construction activity, largely in growth regions (China).
- Determining reasonable CAGRs for the incremental and aggressive scenario in the short and long-term, to extrapolate growth from 2009 onwards.

Assumptions and methods for calculating the market growth of building controls in the European Union and the United States include:

- Determining a base market value[e] in 2005 of US$11 billion and a growth rate of 6 percent, estimated from referencing a building controls market growth report from TAC/Schneider.[36]
- Validating this market value through review of "automation and controls" sales levels from the four largest building controls companies--Siemens,[37] Johnson Controls,[38] TAC/Schneider,[39] and Honeywell[40]--to get an estimate of the overall (controls, including industrial and other) market value in 2008 of US$38 billion. Data from large companies show that the United States and the EU make up 82 percent of the global total, which implies that policies for improving energy efficiency in buildings in these regions could potentially play a significant role in market growth of building controls technologies.
- Cross-referencing the total market values to studies from private market research--Building Services Research and Information Association (BSRIA) and BCC Research.[41]
- Assuming that policies imposing installation of smart meters in residential buildings are a driving factor in promoting growth in the building controls market.

[e] Building controls refers to automation, controls, and building efficiency services, which often include industrial controls and performance contracting services.

ANNEX 2: Quick Facts: The EU Insulation Market

The cost-effectiveness of different insulation applications typically depends on the area of a building treated. Generally, loft insulation is the easiest to apply in existing homes. Installation of high-performance windows can help improve energy efficiency by 30 percent through reducing air-leaks and preventing heat loss,[42] however, new windows are normally less cost-effective than sealing air leaks and improving overall insulation. Applying additional external wall insulation is typically more difficult. These measures of installing insulated windows and adding external wall insulation may require large investments early in the renovation process, while savings are achieved over a period of years, creating a potential need for financing.

Insulation material is typically characterized by its heat transfer coefficient, or U-value. The U-value measures the rate of heat transfer through a building element over a given area, under standardized conditions.

Key determinants of insulation in the European Union:

- **Climate:** The geographic location of the EU member states results in a wide range of climates.

- **Building age:** Of 196 million residential buildings in the European Union, 70 percent are over 30 years old.[43] Many of these old buildings are in need of renovation, and installation of thermal insulation is a critical factor in improving energy efficiency.

- **Building type:** Buildings made from stone, brick, wood frame, or steel frame require different types of insulation.

- **Retrofits:** retrofitting insulation in existing dwellings can be complicated by modifications to the building's exterior shell or by adding insulation on interior surfaces because it often involves breaking through existing structure.

- **Health concerns:** Spray polyurethane foam (SPF) foam products are particularly effective in sealing air leaks and reducing energy loss; however, they are also known to present occupational risks to unprotected applicators. Eye, skin, and inhalation exposure to SPF can cause respiratory diseases, lung damage, asthma, and other ailments.[44] These factors open up new opportunities for the emergence of sealants and insulating materials that are safer to apply and use.

Types of insulation:

- **Stone wool:** Also known as mineral wool, made from furnace product of molten stone. It comes in the form of blankets or loose-fill (blown in). Stone wool products are estimated to make up roughly 25-30 percent of the EU insulation market.[45]

- **Glass wool:** Insulators made from strings of glass arranged into a spongy texture. It comes in the form of blankets or loose-fill (blown in). Glass wool products are estimated to make up 25-30 percent of the EU insulation market.[46]

- **Foam:** comes in two main types--polyisocyanurate and polyurethane. Foam is usually applied to exterior wall cavities because it acts as a very effective air barrier. Foam products are estimated to make up 40-45 percent of the EU insulation market.[47]

ANNEX 3: Quick Facts: The Global Lighting Market

Lighting markets in the developed world are highly centralized, with a few major manufacturers dominating market share.[48] However, due to the lucrative nature of the market, new opportunities to invest are becoming available. China is now the largest producer, exporter, and consumer of lighting equipment. For this reason, our global analysis of projected market growth in the sector factored in the impact of China's light efficiency policies and demand for its products in the United States and the European Union.

Key determinants of lighting in the global market:

- **Chinese policies:** According to J. Kejun, author of *Energy Efficiency Improvement in China*, "The frequency of policy making [in China] is extraordinarily high. There was nearly one new policy per week in 2007 on energy conservation from the central government."[49] Some energy conservation policies focused on lighting have been initiated under the current national economic growth strategy, the 11th Five-Year Plan (2005-2010). One high profile example has been the China Green Light Project;[50] a more recent project of the China government and the Global Environment Facility (GEF), PILESLAMP, aims to phase out incandescent light production and sales by 2012.[51]

- **The "disruptive" nature of lighting technology:** LEDs are the fastest growing lamp segment of the global lighting market, mainly because they use up to 80 percent less energy than incandescent lamps and last much longer than incandescent and fluorescent lamps. A Royal Philips Electronics February 2010 report[52] estimates a market growth rate similar to the one used in this paper, in terms of rapid trajectory in the near- to mid-term. The same report states that LED growth estimates would probably be partially driven by the EU regulation to ban incandescent lighting in 2012.[53] Modeling work by the International Energy Agency (IEA) estimates that overall lighting efficiency will improve by 32 percent in 2015, driven for the most part by the large proportion of incandescent lamps replaced by CFLs in the residential sector, and by the use of improved linear fluorescent lighting in commercial applications.[54]

- **Health concerns** related to exposure to mercury vapor from broken fluorescent lamps (whether full-sized or compact) are a serious issue. Governments and nonprofits are heavily involved with ensuring that the public is educated about proper disposal procedures and what to do in the case of a broken lamp.

Types of lighting:

- **Incandescent lamps c**onsist of a bulb containing a wire filament that is heated to emit light. This lighting application is currently the most purchased lamp globally and also the most prevalent technology used in residential lighting applications.[55] However, incandescent bulbs have the lowest efficacies of any modern electric lamp type ranging from 12-18 lumens/Watt (lm/W).[56]

- **Fluorescent lamps i**nclude both linear fluorescent lamps (LFLs) and compact fluorescent lamps (CFLs). A linear fluorescent lamp is a low-pressure discharge lamp that consists of a soda lime glass tube internally coated with phosphors and tungsten wire electrodes. There are three main types of linear fluorescent lamps: T12s, T8s, and T5s. T5s are the most efficient among the linear fluorescents but are not easily integrated

into existing T12 and T8 fixtures. Fluorescent tubes have much higher efficacy levels (60-104 lm/W) and much longer operating lives (7,500-30,000 hours) than incandescent lamps.

- **Compact fluorescent lamps (CFLs)** were developed in response to the 1970s energy crisis as engineers at General Electric began experimenting with smaller designs of fluorescent lights. CFLs have emerged as replacement products for incandescent light bulbs as today's designs allow for seamless integration into existing lighting sockets. CFL power ratings range from 4 to 120W and efficacies range from 35 to 80 lm/W. The high efficacy compared to incandescent lamps means CFLs will consume only one quarter to one fifth of the energy needed to provide the same amount of light. Many different CFL bulb sizes are available, giving consumers multiple options for specific end-use applications. Although initially more expensive, CFLs are estimated to be cheaper over the lifespan of the product (average lifespan of 5,000-25,000 hours) than incandescent bulbs.

- **High-Intensity Discharge (HID) lamps i**nclude several different technologies: mercury vapor, high-pressure sodium, and metal halide. HID lamps generate light by creating an electronic arc across tungsten electrodes. They can be very efficient, have long lifespans, and are relatively temperature-resistant. Mercury vapor lamps are the oldest HID lamps and the high-pressure versions have efficacy levels of 23-60 lm/W and lifespans of 6,000-28,000 hours. Standard high-pressure sodium lamps have the highest efficacy of all HID lamps with ratings of 70-140 lm/W and lifespans of 5,000-28,000 hours.

- **Light Emitting Diodes (LED)** are an emerging lighting technology first produced in the 1950s by British scientists and have been used in many different applications. For example, LEDs have replaced vacuum tubes in televisions, radios, and computers. Solid state lighting applications have a very long life, up to 11 years, even under extreme conditions. There are two basic types of LEDs, inorganic (gallium-nitride or GaN) and organic. LEDs have the largest upfront costs but this initial investment may be recouped through the longer life of the product and lower operating costs. Organic LEDs (OLEDs) are still at the R&D stage. Commercially competitive brightness levels have been achieved in the laboratory but the development of manufacturing processes presents commercialization hurdles.

TABLE 7: The Relative Benefits of Different Lamp Types

Lighting Type	Lifetime (hours)	Efficacy (lumens/Watts)	Energy Consumption in Comparison to Incandescent Lamps (%)
Incandescent Lamps	750-1,500	12-18	Consumes 19 % of all global electricity
Fluorescent (CFLs, T8, & T5)	6,000-10,000	60-100+	75 % less than incandescent lamps
High-Intensity Discharge	5,000-28,000	47-105	n/a
Solid State (including LEDs)	Up to 100,000	20-50	80% less than incandescent lamps

ANNEX 4: Quick Facts: Building Controls Market

There is wide recognition among policymakers in the European Union and the United States that delivering lower energy use requires having the necessary tools in place so that buildings can be properly operated, measured, and monitored to deliver expected energy performance. Building controls systems provide a variety of functions, including comfort and energy use control, often integrated with security and fire protection control systems.

Key determinants of building controls in the EU and U.S. markets:

- **Green, high performance buildings use and require more sophisticated control systems** often with a related need for greater ongoing services from manufacturers and vendors. There is growing recognition that sophisticated controls in commercial buildings need to be operated by more highly trained staff to ensure that expected energy (and other) cost savings are delivered. This is resulting in more widespread "building dashboards"--transferring the concept of motor vehicle dashboard feedback devices that give the driver real time feedback, to operators "driving" sophisticated buildings who require similar feedback in order to make informed operating decisions.

- **Sophisticated building controls have traditionally been used in larger buildings, but both markets are quickly expanding.** Building controls systems sometimes referred to as "Building Automation Systems (BAS)" or "Energy Management & Control Systems" (EMCS) have controlled comfort conditions in many larger commercial and institutional buildings for decades. According to the most recent Commercial Buildings Consumption Survey produced by the U.S. Department of Energy's Energy Information Administration, only about 5 percent of all commercial buildings have EMCS installed, though that rises to 42 percent of buildings over 100,000 square feet (approximately 10,000 square meters).[57] These larger buildings are only 2 percent of the number of commercial buildings in the U.S. building stock, but make up 34 percent of the total constructed floor area.

- **A relatively small number of controls system manufacturers make up the majority of the market.** Several global controls companies, including Johnson Controls, Siemens, Honeywell, and Schneider control large portions of the building controls market in the EU and North America. While product sales growth has been relatively flat, integrated system sales have been growing at a more rapid pace, and the larger global companies have been acquiring smaller firms, leading to industry consolidation . Recent private market research conducted by BSRIA/Proplan on the size of the Intelligent Building-Environmental Controls ("IBC(e)") in the EU(7) market showed significant growth over the last three years for IBC(e) system sales, running at nearly 7 per cent per year although only a modest 0.5 percent annual growth in IBC(e) product sales. They estimate that total IBC(e) systems market (a subset of overall building controls systems) in 2007 was worth €2.723 billion.[58]

- **Building Energy Performance Labeling is growing in importance, and controls systems help building owners and operators understand end-use contributions to whole building energy use.** The European EPBD requires "Display Energy Certificates" and "Energy Performance Certificates" on buildings in member countries, mandating disclosure of whole building energy performance. Similar U.S. initiatives include California's AB 1103, adopted in October 2007, requiring that as of January 1, 2009, utilities must

be ready to upload energy data to the U.S. Environmental Protection Agency's ENERGY STAR benchmarking system for any customer who requests it. From 2010, commercial buildings were also required to disclose ENERGY STAR benchmarks to prospective buyers, lessees, or lenders.

Types of building controls:

- **Controls systems** offer advanced levels of sensing and automated response to changes in the internal and external environment. From an energy efficiency perspective, building controls offer energy savings by optimizing the use of commercial HVAC, lighting, and other appliances. Controls systems may operate effectively as stand-alone models such as occupancy sensor-based lighting controls or may also operate as central systems. Central systems operate on a building-wide scale and require communication between the different system components such as sensors, actuators, and controllers to affect appropriate control actions. A range of technologies are deployed, including energy management and control systems, occupancy sensors for lighting controls, photo sensor-based lighting controls, and demand controlled ventilation.

- **Energy management control systems** are centralized systems that receive and monitor information from various sensors deployed in the building. They allow the building owner to control actions based on the sensors' outputs. The equipment consists of a central or distributed computing device, communications wires or pathways, sensors, actuators, and information software. Studies estimate that energy management control systems are capable of delivering energy savings between 5 and 15 percent with payback periods of 8 to 10 years.[59]

- **Occupancy sensors** have been around for over 20 years and serve roughly 10 percent of commercial building floor space.[60] The most common occupancy sensor types are infrared and ultrasonic. These typically include a timer to compensate for when people are in a room but not moving and can either be stand-alone or integrated with an energy management control system. Some can also be used to control HVAC systems, for example, in a hotel or conference rooms. Lighting sensors are capable of delivering energy savings between 20 and 28 percent with payback periods ranging from 1 to 5 years.[61]

- **Photosensor based lighting controls** detect the lighting level and dim artificial lighting when appropriate. These systems can save energy when used to automatically dim artificial lights in response to higher space light levels arising from daylighting or overlamping. In building spaces with ample daylight, photosensors dim the artificial lights to compensate for increased natural light and maintain design lighting levels. Photosensors for lighting control are capable of achieving energy savings between 20 and 60 percent with payback periods ranging from 1 to 7 years.[62]

- **Demand control ventilation** adjusts building ventilation to meet real-time occupancy levels. These measures regulate the amount of outdoor air coming into a building on the basis of varying occupancy levels. Demand control ventilation may achieve energy savings from 10 to 15 percent with a payback period of 2 to 3 years.[63]

- **Smart metering** enables the two-way flow of data on energy demands between energy providers and their customers. It is estimated that using smart or advanced meters can cut energy consumption by 5 to 10 percent.[64] The smart meter market is made up of meter manufacturers, metering infrastructure providers (hardware and software needed to collect and deliver data), and meter data management providers (store and analyze data coming from smart meters). The metered information is available for whole building use at any given period of time (hourly or daily). The information from the meters can enable consumers to manage or change their consumption habits.

ANNEX 5: Barriers to Promoting Energy Efficient Technologies in Buildings

Persistent market-related, structural, and behavioral barriers have prevented full realization of investments in energy efficient technologies in buildings. However, in recent years successful strategies have emerged to overcome some of these barriers.

The table below identifies a series of barriers impeding the uptake of energy efficient building technologies. They are broadly categorized as market-related, structural to the industry, and behavioral-related. However, they are not insurmountable and have not halted the growth of, or the market potential for energy efficient building technologies. The examples show that strategies and opportunities are emerging to tackle these barriers and pave the way for investors to reap new rewards from building energy efficiency.

Many of the measures to promote energy efficiency in buildings yield an economic return by reducing energy costs. The only reason why it is challenging to expect short-term payback periods is because of the barriers listed below.

TABLE 8: Challenges and Opportunities in Building Energy Efficiency

	Existing Challenges	Opportunities	Examples of Opportunity Trends
Market-Related Risks	**"Split Incentives"** • Investor does not receive proportionate return from reduced energy costs • Absence of national policy to tackle the problem	• Municipal and state mechanisms such as adoption and updating of building codes are emerging to redistribute financial costs and benefits among builders, owners, and tenants	• Property Assessed Clean Energy (PACE) model introduced in various cities in the United States • "Green Tenant Toolkit" introduced in California
	Risks from Economic Downturn • Access to credit • Increased competition for more limited investment flows	• Government stimulus and subsidy • Increasing investor appetite	• American Recovery and Reinvestment Act, 2009
	Limited Information • Appropriate technologies for building professionals • Return on investment for building owners • Financial data for investors • Expertise in building operations and maintenance	• Online information from government and businesses on marketplace technologies and financing options • NGO platforms for dialogue and information sharing between stakeholders	• Government websites • NGO initiatives that disseminate information and stimulate debate • Directive Certification scheme for new and existing buildings

TABLE 8 (continued): Challenges and Opportunities in Building Energy Efficiency

	Existing Challenges	Opportunities	Examples of Opportunity Trends
Industry Risks	**Fragmentation** • Building professionals operate independently • Miscommunication and lack of coordination	• Maximization of existing resources and networks	• European Performance Buildings Directive promotes engineer involvement early on in the design process • Increasing availability of holistic education and training courses • Integrated design and operations
	Behavior Inertia • Reluctance to change behavior particularly given uncertainty about financial returns	• Government initiatives using push to modify behavior	• EU Electricity Directive aims to install smart energy meters in 80% of European homes by 2022

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