McKinsey&Company

Pathways to World-Class Energy Efficiency in Belgium

Preface

Belgium faces a combination of challenges: a global economic crisis with serious implications for the country's economic fabric, highly volatile prices for natural resources, growing competition in international markets and an urgent need to cut greenhouse gas (GHG) emissions to comply with current and future international commitments.

Leaders in many nations have decided to set ambitious targets for higher energy efficiency. These represent the most cost-efficient lever for reducing GHG emissions in most developed economies. Moreover, implementing energy efficiency measures can create jobs, improve competitiveness and reduce dependence on energy imports. Belgium has the potential to save a great deal of energy across all economic sectors: the country's energy efficiency is currently among the lowest in Europe and those initiatives already planned or implemented to improve its energy efficiency will not do enough to keep the country in step with the rest of the continent.

To provide a basis for discussions on energy efficiency, McKinsey & Company collaborated with the Federation of Enterprises in Belgium (FEB-VBO), representing 33,000 businesses in Belgium from 33 sector federations. As a result of these efforts, McKinsey has developed a perspective on pathways leading to world-class energy efficiency in Belgium. This report presents our findings: the potential for higher energy efficiency, the related costs, and the available measures for improving efficiency in the highest energy-consuming sectors. It includes a comprehensive review of potential measures and illustrations of international best practices. A summary of this report is available in English, Dutch and French at www.mckinsey.be/energyefficiency.

This study builds on McKinsey's Global Greenhouse Gas Abatement Cost Curve and more than 10 national GHG abatement cost curves developed over the past 3 years. The purpose of this report is to provide an objective, uniform set of data, amplified by examples from other countries, that can serve as a starting point for debate between corporate leaders, policy makers and other decision makers on how best to improve energy efficiency in Belgium. It does not prescribe any specific policy choices.

We would like to thank the FEB-VBO and the members of the Advisory Council – Flanders' Chamber of Commerce and Industry (VOKA), the Walloon Union of Enterprises (UWE), the Federal Planning Bureau, the Federal Public Service Health, Food Chain and Environment, Bond Beter Leefmilieu and Ghent University – for their invaluable contributions to the methodology and content of this study. Finally, we would like to thank FEB-VBO's different sector federations for their collaboration during this study.

Ruben Verhoeven
Director

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Introduction

Four elements make the case for improving energy efficiency in Belgium. First, McKinsey's research on the potential to decrease greenhouse gas (GHG) emissions worldwide shows that energy efficiency measures account for about 38 percent[1] of the global GHG emission savings potential. Failing to initiate energy efficiency improvements now may make it hard for Belgium to meet GHG targets likely to be negotiated under the UNFCCC-led discussion on the Global Deal in Copenhagen in December 2009 without taking more drastic measures later. Second, beyond the environmental burden, high energy consumption represents an important cost to society in an export-dependent economy such as Belgium. Third, energy inefficiency makes the country more vulnerable to fluctuating commodity prices and geopolitical risks. Finally, improving energy efficiency could improve Belgium's competitive position and create a significant number of local jobs. Belgium's neighbors have already taken up the challenge and initiated major schemes to improve their energy efficiency.

Our analysis addresses technical and behavioral opportunities for improving energy efficiency in Belgium rather than a wider range of levers for reducing GHG emissions, which would include, for example, changing the national energy and fuel mix, revising agriculture and land use, and adopting new technologies such as carbon capture and storage, or white biotechnology. We chose to focus on improving energy efficiency because this is the lowest-cost means of reducing Belgium's GHG emissions, more powerful even than shifting to low-carbon energy. In addition, it involves us all: improving the country's energy efficiency requires an effort from everyone across society – individuals, private sector, public sector and NGOs.

This report is organized in four chapters. The first chapter describes where Belgium stands in terms of energy efficiency today and where it is heading, and analyzes the economy's overall energy efficiency improvement potential. The next three chapters discuss in detail the improvement potential in the three sectors that consume most energy – Buildings, Road Transportation and Industry. In the concluding remarks, we emphasize the role education can play in enhancing awareness of energy efficiency and the need for an integrated, long-term approach to improving energy efficiency in Belgium.

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[1] In Version 2 of McKinsey's Global Greenhouse Gas Abatement Cost Curve, energy efficiency and behavioral measures represent respectively 14 and 4 gigatonnes (Gt) CO_2e savings potential compared to the total theoretical savings potential of 47 $GtCO_2e$ by 2030.

Methodology and definitions

The *business-as-usual scenario (BAU)* or forecast for 2030 is based on primary energy demand in 2005 as defined by Eurostat, and uses NTUA "PRIMES" projections[2] to forecast primary energy consumption until 2030. PRIMES projections take into account all known legislation. They were chosen for this report because they are accepted by governments (they are used by the European Commission and the Federal Planning Bureau in Belgium) and can be compared with historical and future time series data, as well as data on all other EU countries' economic activity. The BAU scenario includes expected energy efficiency improvements if current policy and incentive structures deliver their full potential impact. Any additional measures improving energy efficiency, including those considered in the improved energy efficiency scenario defined below, would require the private and/or the public sector to initiate new measures.

The *improved energy efficiency scenario* assumes that both additional investment-related and non-investment-related energy efficiency improvement measures are implemented as a result of more ambitious societal decisions and energy efficiency policies. Industrial activity and product mixes in this scenario, however, are assumed to be the same as in the BAU scenario. The energy savings potentially gained as a result of such additional measures are referred to as the *theoretical energy savings potential.*

Energy consumption is expressed in *barrels of oil equivalent (boe)*, which corresponds to the amount of energy released by burning one barrel of crude oil[3].

The *Global Greenhouse Gas Abatement Cost Curve* was first published by McKinsey in 2007 and updated in January 2009. The underlying research identifies more than 200 GHG abatement opportunities (including many opportunities relating to energy efficiency) across 10 sectors in 21 regions. It assesses the cost and abatement potential of all these levers to 2030, assuming a crude oil price of $62/bbl.

Belgium's total theoretical energy savings potential from *investment-related energy efficiency measures* is adapted from data on Germany from McKinsey's Global Greenhouse Gas Abatement Cost Curve Version 2. An "energy efficiency cost curve" for Belgium was developed by retaining only the abatement levers that improve energy efficiency and, where appropriate, by adapting both input parameters and impact estimates to the Belgian context[4]. The energy efficiency cost curve displays the energy savings potential of individual levers relative to the BAU scenario, as well as the corresponding crude oil price at which each lever becomes Net Present Value (NPV)-positive[5]. The width of each bar represents the theoretical energy savings potential (not a forecast) from that lever. The potential volume of energy saved by 2030 assumes concerted action starting in 2010 to

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[2] NTUA (Baseline EC-DG TREN: Nov 2007).

[3] 1 boe = 0.136 tonne of oil equivalent (toe) = 6.12 gigajoule (GJ) = 1699.81 kilowatt hours (kWh).

[4] In Buildings, for example, Belgian statistics were used for floor space, heating degree days, penetration of double glazing, etc.

[5] Net Present Value is the value of the net profit of an investment taking into account all investment costs and future cash flows made during the lifetime of the project, discounted at year 0.

capture each opportunity and reflects the total active installed capacity of that savings lever in the year 2030, regardless of when that capacity has been installed.

The total theoretical energy savings potential from *non-investment-related* measures such as behavioral changes was based on observations on the ground for Industry and developed from literature research and expert interviews for Buildings and Road Transportation.

The analysis adopts a *societal perspective*, meaning that taxes and subsidies have not been taken into account, and the capital cost for NPV calculations is assumed to be similar to government bond rates, i.e., 4 percent. This perspective allows for comparisons of opportunities and costs across sectors and individual companies. However, it also means that the calculated costs and benefits of an opportunity analyzed in the report may differ from those a company or consumer would recognize, as the latter would include taxes, subsidies, and higher discount rates in their cost/benefit calculations. The cost of each opportunity also excludes transaction and program costs such as costs for research and administration.

Primary energy consumption indicates the total energy use in a given country. When assessing the energy and GHG emissions that can be saved for the benefit of a given economy from a societal perspective, it is necessary to work with primary energy consumption numbers.

Final energy consumption indicates the energy available for final use after transformation and distribution. Feedstocks, i.e., energy products used as raw materials in producing other products (e.g., coking coal used in a blast furnace to produce steel, gas cracked in a petrochemical plant to produce chemicals) are not included in the final or primary energy numbers.

Energy requirements for Buildings include all energy requirements for heating, cooling, lighting, and running appliances and electronics in residential buildings and commercial buildings. Commercial buildings include stores, offices, schools, hospitals, and public administration buildings, and exclude industrial buildings.

Energy requirements for Road Transportation include all energy requirements for the transportation of people and goods in Belgium by road, and are inferred from energy purchases on Belgian territory.

Energy requirements for Industry include all energy requirements for industrial activities, including heating, cooling and lighting industrial buildings, but not the energy contained in feedstocks.

1. Identifying a significant theoretical energy savings potential

This chapter examines Belgium's total theoretical energy savings potential. It describes where Belgium stands today in terms of energy efficiency and explains where the country could be by 2030 if it were to take more ambitious efficiency initiatives.

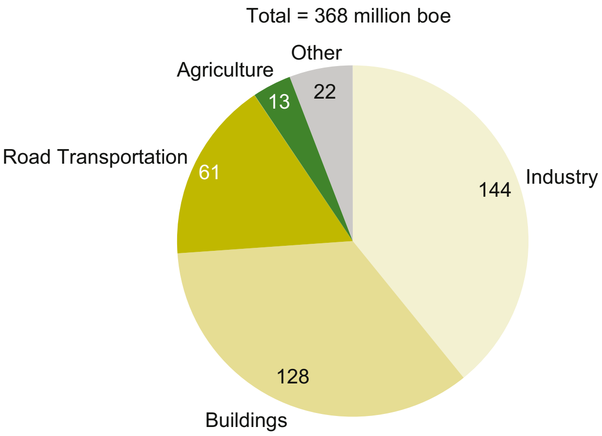
1.1 WHERE BELGIUM STANDS AND WHERE IT IS HEADING

Primary energy consumption in Belgium – or gross inland energy consumption – amounted to 368 million boe in 2005. Ninety percent of this consumption derived from three sectors, Buildings, Road Transportation, and Industry. These consumed 128 million boe, 61 million boe and 144 million boe respectively (Exhibit 1). The remaining consumption stems mostly from agriculture and other modes of transportation.

Exhibit 1

Breakdown of primary energy consumption in Belgium

Boe Millions, 2005



SOURCE: NTUA (PRIMES forecast 2007)

All three sectors are currently less energy-efficient than their counterparts in neighboring countries. Belgian energy consumption per square meter in residential buildings is more than 70 percent higher than the EU average. Fuel consumption per passenger-kilometer in Road Transportation is one of the highest in Europe, and is not declining. It is more difficult to compare energy consumption in Industry across countries because of differences in their industrial activity mix. However, the annual energy efficiency improvement targeted by Industry in Belgium is 20 to 40 percent below the target in other European countries.

With currently planned energy-saving measures – what we term the "business-as-usual" (BAU) scenario – the country's primary energy consumption is expected to reach 390 million boe in 2020 before decreasing and stabilizing around 366 million boe in 2030. This stabilizing trend can be explained by efficiency improvements in the energy production chain itself and by the nuclear phase-out expected in line with the current legislation. By scientific convention, energy efficiency of combined-cycle gas turbine plants and high-efficiency coal plants is higher than energy efficiency in the nuclear power plants they will replace. Based on this assumption, at a crude oil price of $62 per barrel (bbl)[6], the country's total energy consumption would represent a cost of €15.1 billion in 2030, or 3 percent of projected 2030 real GDP. As a result, GHG emissions in 2030 would amount to 185 megatonnes (Mt) CO_2e[7], of which 47 $MtCO_2e$ would come from Buildings, 26 $MtCO_2e$ from Road Transportation and 77 $MtCO_2e$ from Industry.

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[6] Assumed cost: $62/bbl (source: PRIMES); exchange rate: 1.5 $/€.

[7] CO_2e is "carbon dioxide equivalent", a standardized measure of GHGs such as methane. Emissions are measured in metric tonnes of CO_2e per year, i.e., millions of tonnes (megatonnes) or billions of tonnes (gigatonnes). The greenhouse gas forecast in this report differs from the forecasts made by the European Commission's DG for Energy and Transport, because of differences in the CO_2 intensity of energy carriers and the different treatment of "non-marketed steam".

1.2. WHERE BELGIUM COULD BE IN 2030

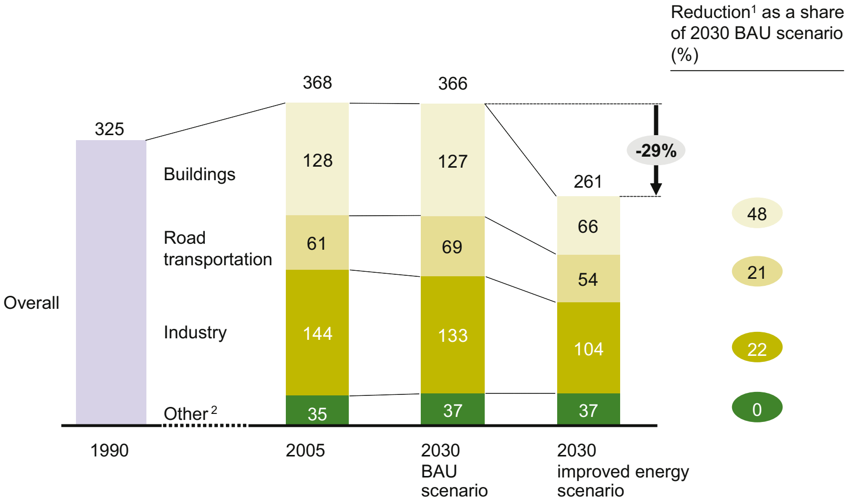
Our analysis has identified a theoretical energy savings potential representing 29 percent of the BAU scenario or 105 million boe in 2030, when measured in terms of primary energy demand (Exhibit 2). When looking at it from the end-user perspective, in terms of final energy demand, our analysis shows a theoretical energy savings potential representing 28 percent compared to the BAU scenario (Exhibit 3).

The cost curve demonstrates how different levers across all sectors contribute to the overall energy savings potential (Exhibit 4). The largest improvement potential can be found in Buildings, with 61 million boe of potential savings (48 percent of 2030 primary energy consumption in the BAU scenario) followed by Industry with 29 million boe (22 percent of BAU) and Road Transportation with 15 million boe (21 percent of BAU). The savings come not only from measures requiring additional investments but also from changes requiring no incremental capital expenditure. The latter either relate to behaviors or arise from investments that would have been made anyway, for example, the beneficial energy efficiency effects of increased industrial throughput.

Exhibit 2

Scenarios for primary demand evolution in Belgium

Boe Millions



1 Expressed as primary energy; consumption slightly decreases between 2005 and 2030 due to changes in energy fuel mix and efficiency gains in conversion

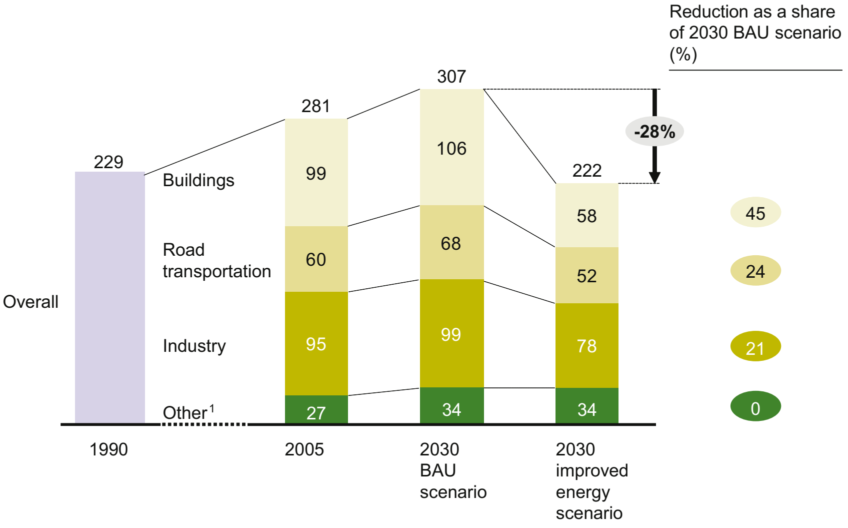
2 Not considered in the analysis

SOURCE: NTUA (PRIMES forecast 2007); McKinsey analysis

Exhibit 3

Scenarios for final energy demand evolution in Belgium

Boe Millions

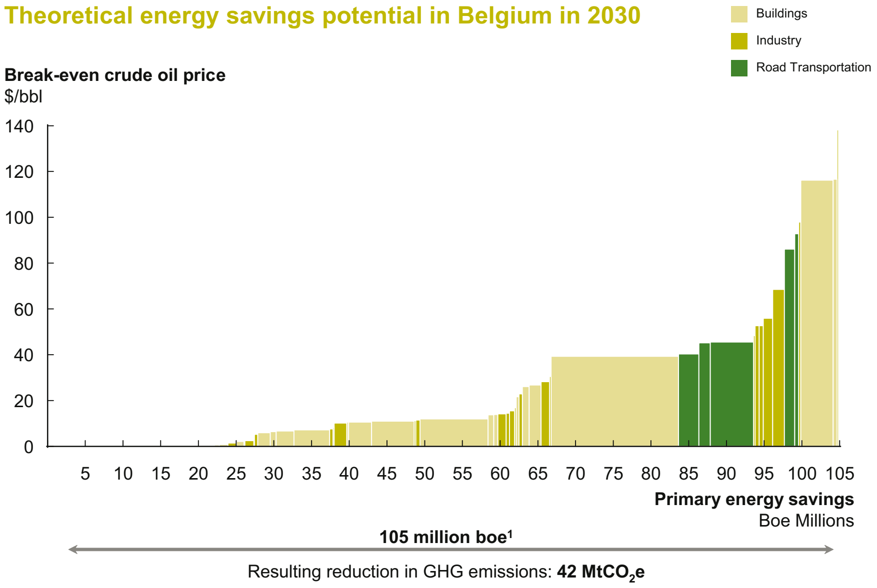


1 Not considered in the analysis

SOURCE: NTUA (PRIMES forecast 2007); Global Insight; McKinsey analysis

Exhibit 4

Theoretical energy savings potential in Belgium in 2030



Resulting reduction in GHG emissions: **42 MtCO$_2$e**

1 Includes behavioral changes (22 million boe)

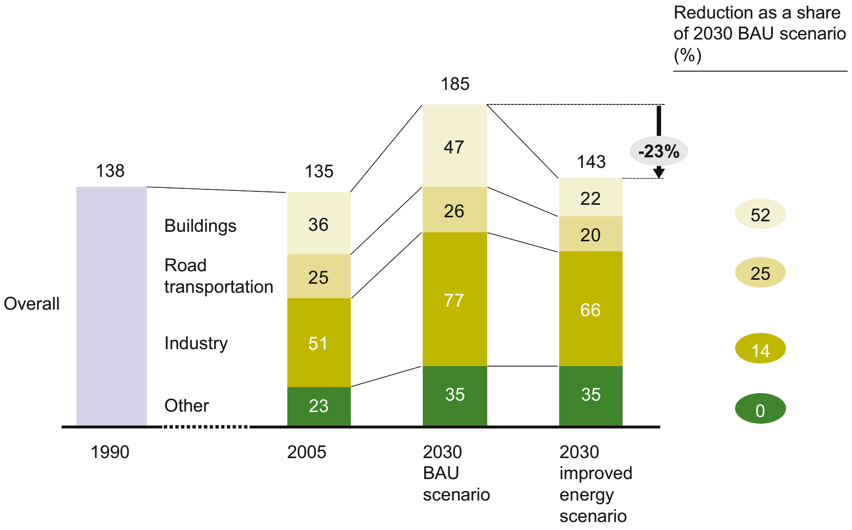
SOURCE: McKinsey Global Greenhouse Gas Abatement Cost Curve v2.0; UNFCCC; McKinsey analysis

The value at stake is significant. The theoretical energy savings potential identified represents a total annual saving of €5.2 billion[8] for the country as a whole, equivalent to the primary energy consumption of 3.1 million households in 2008[9] or almost 1 percent of projected GDP in 2030. The positive impact on GDP would be even higher if the multiplier effect of energy savings (additional capital invested or spent domestically) and the improved competitiveness of the country's industry were taken into account. Achieving the identified energy efficiency improvements would also stabilize Belgium's GHG emissions at 42 $MtCO_2e$, around 2005 levels, making them 23 percent lower by 2030 than in the BAU scenario (Exhibit 5). This in itself would not be enough to achieve Belgium's "20-20-20" target[10] in the agreed time, but would nevertheless move Belgium a lot closer to its target. Finally, improving energy efficiency would reduce Belgium's exposure to fluctuating commodity prices and geopolitical risks, and stimulate job creation.

Exhibit 5

Scenarios for greenhouse gas emissions evolution in Belgium

$MtCO_2e$



SOURCE: NTUA (PRIMES forecast 2007); UNFCC; Global Insight; McKinsey analysis

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[8] At $62/bbl and 1.5 $/€, and adjusted for the added value contained in different energy carriers. These savings can be broken down into €2.9 billion for Buildings, €1.1 billion for Road Transportation, and €1.2 billion for Industry.

[9] Eurostat, Euroconstruct.

[10] Following the European Commission's proposals in January 2007, all heads of state and government of the European Union committed in December 2008 to cut the EU's GHG emissions by 20 percent by 2020, or 30 percent as part of an international agreement. They have also committed to a 20 percent increase in renewable energy and a 20 percent increase in energy efficiency by 2020.

We estimate that achieving the identified potential would entail a yearly incremental investment spread across all sectors of €1.6 billion between 2010 and 2020 and of €2.2 billion from 2020 to 2030. At a crude oil price of $62/bbl, 93 percent of these investments would be NPV-positive. Moreover, such investments are likely to produce multiple new business opportunities by creating new markets for efficiency-related products and services. This is especially the case in Buildings and Road Transportation, but Industry, too, could require innovative products and services that Belgian companies can develop and provide.

1.3 REACHING THE IDENTIFIED POTENTIAL

It is one thing to have the potential to make significant energy efficiency improvements; it is another for individuals, companies and policy makers to realize that potential. Capturing all the opportunities would entail change on a large scale and require effort from all stakeholders, whether in households or across the public and private sectors. Our analysis shows that the most viable path to significant and cost-effective energy efficiency improvements entails complementary measures in all sectors of the economy and involves all stakeholders, including the educational system. Learning from ambitious initiatives in other countries, we have identified a set of measures for each of Belgium's highest energy-consuming sectors. Taking these measures could turn Belgium into one of the world's most energy-efficient economies.

2. Improving energy efficiency in Buildings

With an improvement potential of 61 million boe, residential and commercial buildings represent the largest share of the total energy efficiency improvement potential in Belgium. This chapter describes the potential available in the Buildings sector, addressing where the sector stands today, where it could be in 2030 and possible pathways to higher energy efficiency in Buildings.

2.1 WHERE BELGIUM STANDS AND WHERE IT IS HEADING

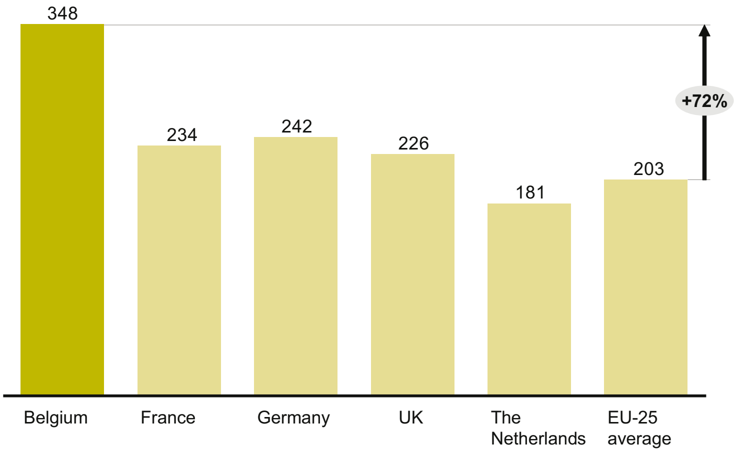
In 2005, Belgium's residential and commercial buildings were responsible for 35 percent of primary energy demand (128 million boe). Residential buildings accounted for 73 percent of Buildings' primary energy demand, with the commercial sector accounting for the remainder. Within commercial buildings, primary energy demand mainly comes from schools (30 percent), hospitals (30 percent) and public administration offices (30 percent). Energy in buildings is consumed chiefly in heating, cooling and lighting.

With an average energy usage of 348 kilowatt hours (kWh)/m^2/year, Belgium's energy efficiency in residential buildings lags that of other Western European countries, as well as the European average of 203 kWh/m^2/year[11] (Exhibit 6). Indeed, residential buildings

Exhibit 6

Average residential energy consumption in selected European countries

kWh/m^2, 2005



SOURCE: NTUA (PRIMES forecast 2007); McKinsey Greenhouse Gas Abatement Cost Curve V2.0

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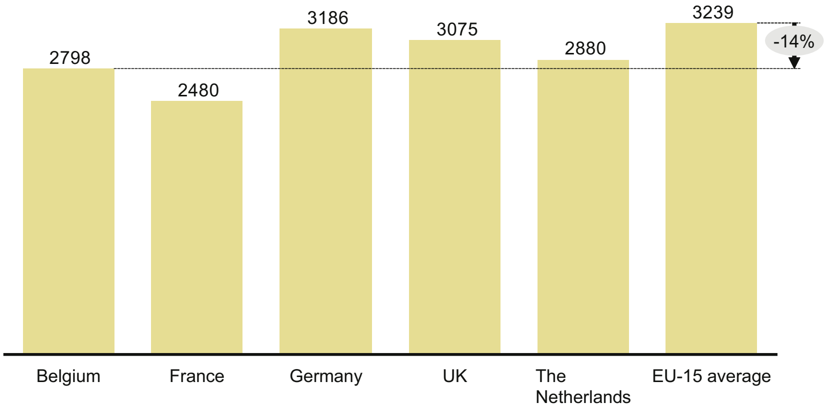
[11] Estimated from McKinsey's Global Greenhouse Gas Abatement Cost Curve Version 2, PRIMES database.

in Belgium have a higher average energy demand than those in many European countries where climate differences suggest there should be heavier demand for energy in heating and/or air conditioning systems (Exhibit 7).

Exhibit 7

Heating demand in selected European countries

Heating degree days[1], 2004



1 Reflect the demand for energy needed to heat a home or business: the difference between a reference value of 18°C and the average outside temperature for that day, summed up for all days in a given year

SOURCE: Eurostat; McKinsey Greenhouse Gas Abatement Cost Curve V2.0; ODYSSEE Indicators

There are three main “technical” reasons explaining the low energy efficiency of Belgian buildings compared to those of other European countries[12]:

- **The age of Belgium’s building stock** (Exhibit 8). Belgium’s buildings are relatively old because of a low demolition rate – at 0.075 percent a year one of the lowest in Europe[13] – and growth in the building stock of only 1 percent, compared to a 1.5 percent average among Belgium’s peers[14]. As the average age of Belgium’s building stock is forecast to increase further than that of European counterparts in the next 25 years, the relative energy efficiency of the building stock is also likely to decrease.

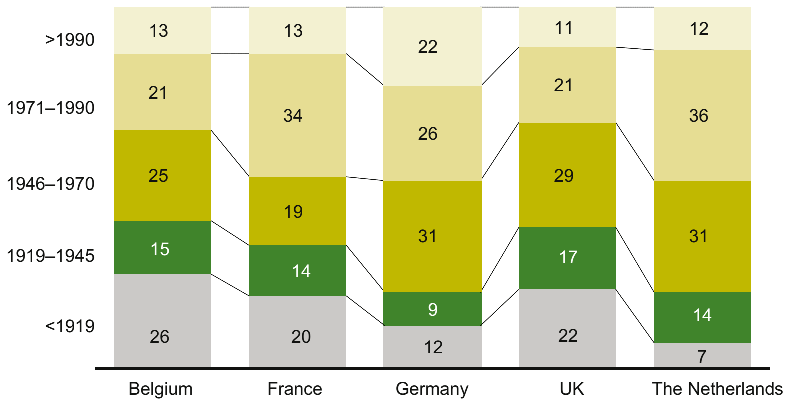
- **A higher percentage of single-family houses** than in other European countries[15]. To illustrate, 53 percent of the German residential stock consists of apartment buildings and houses inhabited by more than one family, compared to only 27 percent in Belgium.

- **A lower penetration of energy efficiency features,** such as double glazing and insulation, than other European countries. In the absence of strict construction standards, only 41 percent of Belgian homes have wall insulation[16]; 36 percent[17] have full double-glazed windows, compared to 71 percent of homes in the UK; 58 percent of Belgian homes have roof insulation compared to 73 percent of homes in the UK[18].

Exhibit 8

Relative age of building stock in selected European countries

Year of construction, percent of housing stock, 2005



SOURCE: Global Energy Reduction Fund: Practical Support Systems & Energy Improvement Loans in Residential Housing; Belgoststat construction data

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[12] Where people are during the day does not affect Belgium’s energy consumption; the percentage of individuals staying at home during workdays was estimated close to the European average.

[13] *Building Renovation and Modernisation in Europe: State of the Art Review,* Erabuild, January 2008.

[14] Belgostat; *Building Renovation and Modernisation in Europe: State of the Art Review*, Erabuild, January 2008.

[15] Statbel.be on Buildings; Federal Statistical Office, Germany.

[16] Fonds de Réduction du Coût Global de l’Energie, December 2008 (using 2001 census data).

[17] *Avis complémentaire à l’avis du 21 décembre 2005 relatif à l’efficacité énergétique dans le secteur du logement en Belgique*, Conseil Central de l’Economie, April 2006 (using 2001 census data).

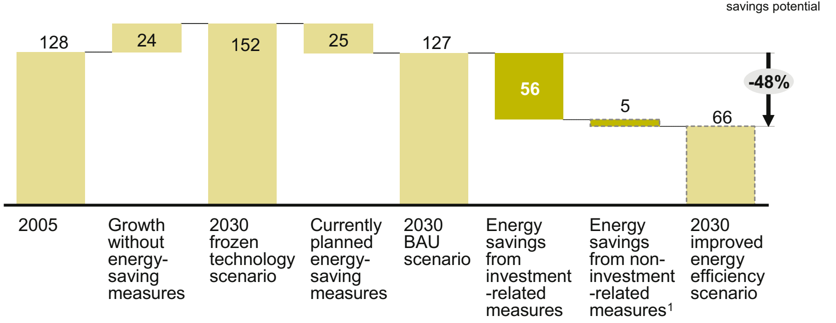
[18] ODPM Survey of English Housing 2004-2005.

In the BAU scenario, energy consumption in Buildings is expected to remain stable at around 127 million boe in 2030, despite an expected 1 percent yearly increase in floor space (Exhibit 9). This scenario assumes energy efficiency improvements will be gained through higher construction standards and the use of more energy-efficient appliances and lighting. The BAU scenario does not take into account any energy-saving impact from full implementation of legislation such as the EU's Energy Performance of Buildings Directive (EPBD) and similar regional initiatives.

Exhibit 9

Scenarios for energy demand evolution in Buildings in Belgium

Primary energy consumption, Boe Millions



Examples of measures	Growth without energy-saving measures	Currently planned energy-saving measures	Energy savings from investment-related measures	Energy savings from non-investment-related measures[1]
	▪ Growth in floor space (1% CAGR[2])	▪ Shift from incandescent lamps to CFLs	▪ High-efficiency building envelopes ▪ High-efficiency heating & cooling systems, appliances and lighting	▪ Reduced usage of HVAC, water heating, lighting & appliances ▪ Structural shift towards smaller houses

[1] Includes behavioral changes

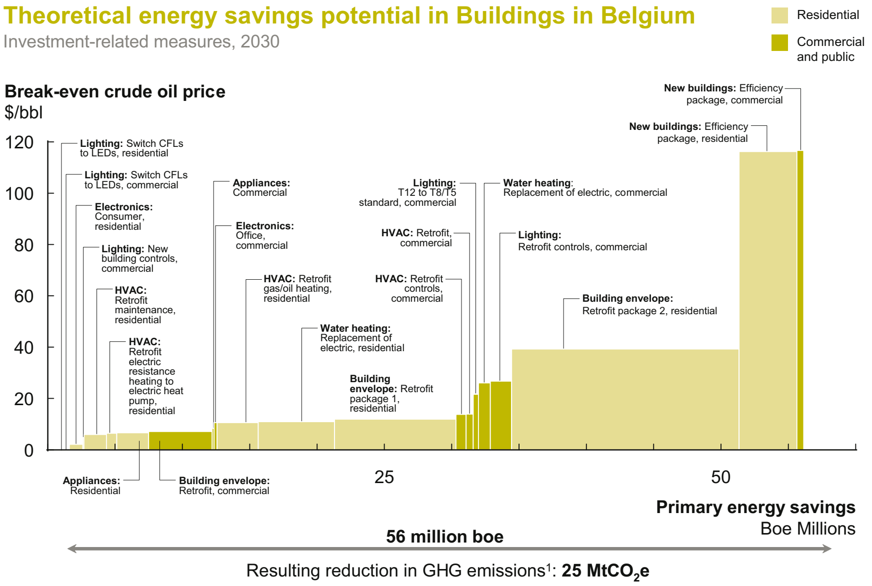
[2] Compound annual growth rate

SOURCE: NTUA (PRIMES forecast 2007); McKinsey analysis

2.2 WHERE BELGIUM COULD BE IN 2030

Our analysis has identified a theoretical energy savings potential of 61 million boe from Buildings by 2030, representing 48 percent of the primary energy consumption expected in Buildings by 2030 in the BAU scenario and more than half of the theoretical energy savings potential in 2030 identified for the whole country. Of the total savings potential, 56 million boe comes from investment related measures (Exhibit 10), of which 51 million boe apply to residential buildings; the remaining 5 million boe of savings would come from behavioral changes. Ninety-two percent of the anticipated investment is NPV-positive at a crude oil price of $62/bbl or less.

Exhibit 10



Theoretical energy savings potential in Buildings in Belgium

Investment-related measures, 2030

1 Includes non-investment-related measures

SOURCE: McKinsey analysis

To capture the full potential, our analysis distinguishes five main categories of energy efficiency measures, the first four of which require additional investments: (1) improving energy efficiency in existing building stock; (2) raising energy efficiency standards for new buildings; (3) improving the energy efficiency of lighting, appliances, and electronics; (4) installing more efficient heating, ventilation and air conditioning (HVACs) and water heating systems; and (5) instilling behavioral changes. Each category comprises a set of levers with different potential savings and costs of implementation.

Improving the energy efficiency of the existing building stock, by renovating residential and commercial building envelopes. This would account for 31 million boe of identified energy savings compared to the BAU scenario. Average energy consumption for heating in existing buildings was 188 kWh/m^2 in 2005 (the weighted average of 223 kWh/m^2 for residential buildings, representing 73 percent of total building space, and 114 kWh/m^2 for commercial buildings, representing 27 percent). The improved energy efficiency scenario assumes Belgium would move to an E30-E60 passive house[19] standard of 15-35 kWh/m^2 for the existing building stock.

Basic improvements could include measures like adding attic insulation, weather-stripping doors and windows and making homes airtight. Such measures would bring 14 million boe[20] in energy savings and would be NPV-positive at $12/bbl. Additional improvements to building envelopes including better insulation for roofs and walls would represent an additional 17 million boe[21] of savings, although they would only become NPV-positive at $40/bbl. Demolition and rebuilding may be preferable in cases where thorough renovations are only marginally cost-effective or not feasible for other reasons.

Raising the energy efficiency standards for new buildings, both residential and commercial. This would include adopting an E30 passive house standard for new buildings (15 kWh/m^2), and generate a savings potential of around 5 million boe. Such investments would only be NPV-positive at $117/bbl. However, new buildings using passive-house standards typically cost only 4 percent more to build than new buildings using current standard technology.

Improving the energy efficiency of lighting, appliances and electronics, for example, by shifting from Compact Fluorescent Lamps (CFLs) to Light-Emitting Diodes (LEDs) and by applying control systems in residential and commercial buildings. These measures would represent a savings potential of 4 million boe and would become NPV-positive at a crude oil price of $27/bbl. Shifting to higher efficiency appliances and electronics could save an additional 4 million boe. These measures would become NPV-positive at $11/bbl.

The average energy consumption of building applications other than space heating, such as household appliances or lighting, amounted to 137 kWh/m^2 in 2005 (the weighted average of 125 kWh/m^2 for residential buildings and 160 kWh/m^2 for commercial buildings). In the improved energy efficiency scenario, the average energy consumption of applications other than space heating would decrease to 131 kWh/m^2 in 2020 (a fall of 4 percent), and to 111 kWh/m^2 in 2030 (a further fall on the 2005 level of 19 percent). This scenario assumes:

- A rise in penetration of high-efficiency white goods appliances from 34 percent of all white goods in 2005 to 100 percent by 2020, saving 38 percent of the current average energy they consume by 2030. This implies that by 2015 only AA-labeled appliances could be purchased.

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[19] A passive house is a building in which a comfortable interior climate can be maintained without active heating and cooling systems. The house heats and cools itself, hence “passive” (source: Passivhaus Institut).

[20] Assumes implementation of measures in 90 percent of all buildings.

[21] Assumes implementation of measures (triple-glazed high-efficiency glazing) in all buildings.

- A rise in penetration of high-efficiency electronics from 19 percent of all electronics used in buildings in 2005 to 67 percent by 2020 and 100 percent by 2030, saving 17 percent by 2030 of the current annual average energy consumed by building electronics.

- A progressive reduction in the sales of inefficient lamps (for example, incandescent bulbs and conventional halogen bulbs in households) in line with EU legislation[22], starting in 2009 and applied in full by the end of 2012; and a higher penetration of LED lights, from an installed base of 0 percent in 2010 to 13 percent in 2020 and 50 percent in 2030.

Installing more efficient HVACs and water heating systems. Performing regular maintenance and shifting from electric water heating to solar and high-efficiency gas and oil heaters could save 12 million boe by 2030 compared to the BAU scenario. The benefits are so significant that even the most expensive of these measures becomes cost-effective at $26/bbl. The improved energy efficiency scenario assumes that penetration of high-efficiency water heating systems would increase from 8 percent in 2005 to 50 percent in 2020 and 90 percent in 2030, and that penetration of high-efficiency HVACs would grow from 34 percent in 2005 to 100 percent in 2020.

Instilling behavioral changes could produce more than 5 million boe in additional savings by 2030 at virtually no cost. Such changes include making less unnecessary use of HVAC, hot water, lighting and appliances, as well as making new buildings 20 percent smaller.

Implementing these five categories of measures would require a total investment of €24 billion between 2010 and 2030. Of this amount, around 85 percent would be invested in residential buildings. Nearly a quarter of the total capital expenditure would have to be spent in the period up to 2015, assuming a linear implementation pattern, and the average payback period of the identified measures would be 8 years. At the same time, implementing these measures could create up to 20,000 jobs[23] and would reduce Belgium's GHG emissions by about 25 $MtCO_2e$ compared to the BAU scenario.

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[22] Commission Regulation (EC) No 244/2009 of 18 March 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for non-directional household lamps. Commission Regulation (EC) No 244/2009 of 18 March 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for fluorescent lamps without integrated ballast, for high intensity discharge lamps, and for ballasts and luminaires able to operate such lamps.

[23] Estimate based on an extrapolation of EU-wide and German employment creation data for the construction industry: *Green Jobs: Towards decent work in a sustainable, low-carbon world*, ILO, 2008; *Climate Change and employment: Impact on employment in the European Union-25 of climate change and* CO_2 *emission reduction measures by 2030*, ETUC, ISTAS, SDA, Syndex, Wuppertal Institute, 2007; *Impact of the EU Energy and Climate Package on the Belgian energy system and economy: Study commissioned by the Belgian federal and three regional authorities*, Federal Planning Bureau, 2008.

2.3 PATHWAYS TO ENERGY EFFICIENCY IN BUILDINGS

Initiatives to date

Public and private stakeholders in the Buildings sector are already pursuing a number of energy efficiency improvements.

On the public side, policy makers have translated legislation and directives into building codes and are providing numerous incentives to promote uptake of energy efficiency measures:

- The EU's Energy Performance of Buildings Directive (EPBD) is the basis for building codes in Belgium. The EPBD mandates the use of energy labels and certificates for new houses and major renovations. The standards are set by the regions and revised every 5 years. For example, both the Flemish "Klimaatbeleidsplan" and the Walloon "Plan Air Climat" define minimum insulation requirements for new buildings although there are differences in their respective definitions. However, the EPBD is not fully implemented yet and its overall impact has yet to be assessed.

- Incentives have been defined at the federal and regional levels. Federal measures include tax rebates and deductions and reduced VAT rates for renovations that meet low energy or passive standards, the construction of low energy and passive houses, and the installation of condensers, high-efficiency HVAC systems, thermal insulation and double glazing. Regional and local authorities also offer incentives for such measures. East Flanders, for example, offers a 6 percent VAT rate for renovations that improve energy efficiency in houses older than 5 years. This is in addition to a Flemish renovation premium of up to 30 percent of the investment, federal tax incentives of €790 per year if the renovation reaches passive standards and – for many communes – 2 hours of free advice from an architect.

Organizations in the private sector have also launched several initiatives to raise energy efficiency, for example, through improving building materials and through individual or cross-industry efforts to promote the efficient use of energy, such as the "Massive Passive" initiative jointly developed by a brick manufacturer and an insulation material manufacturer, and "CAP2020", a group of 82 partners for sustainable construction in Wallonia. Public-private partnerships (for example, a recent project to build 211 new energy-efficient schools in Flanders) are also on the increase.

However, a number of difficulties intrinsic to renovating buildings may prevent such public and private sector initiatives from reaching their full potential:

- People are not aware of the relatively short payback times of some energy saving measures and incentives (Exhibit 11).
- While most investments are NPV-positive at relatively low oil prices and have a short payback time, their high upfront cost makes them difficult for many owners to invest in, especially as any financial incentives generally arrive after some delay. Customer financing, ESCO-based funding and third-party financing (mainly leasing) are all available in Belgium, but there are no government policies to encourage or enforce their use to promote household investment in energy-efficient buildings.
- The annual cap set on most incentives deters home owners from undertaking comprehensive renovations in one project. It encourages them rather to spread investments over several years in smaller, incremental renovations.
- Owners of property rented out for residential or commercial purposes have few incentives to invest in meeting higher energy efficiency standards (upfront or as part of a renovation) because it is the tenant, not the owner, who benefits from such improvements.
- A number of energy efficiency measures, for example, wall insulation, entail vacating the building during their installation, an obvious hurdle to major renovation projects.

Exhibit 11

Lack of knowledge on energy efficiency economics

Example of roof insulation, Brussels, 2008

Cost of work	Mineral wool 16 cm + vapour barrier + labour + VAT 6%	
	= ~40 €/m^2 x 70m^2	€2800
Payback time without premium and tax reduction	CAPEX of installation/reduction in OPEX (fuel savings)	
	= €2800 / €658 /year	**4.3 years**
Tax reduction	40% of investment, up to €2650 per fiscal year	
	= 40% x €2800	€1120
Premium Brussels Region	20 €/m^2 (max 50%)	
	= €20 x 70m^2	€1400
Net cost	= €2800 - €1120 - €1400	€280
Payback time with premium/tax reduction	= €280 / €658 /year	**<5 months**

SOURCE: Global Energy Reduction Fund: Practical Support Systems & Energy Improvement Loans in Residential Housing

- For renovations to public buildings, decision cycles tend to be long as multiple stakeholders need to be consulted and aligned before any decision can be made. They also involve choosing among multiple investment priorities to keep within tight budgets.

An integrated approach to reach the full potential

Realizing the full potential from the Buildings sector identified in the improved energy efficiency scenario, would require implementing an integrated set of measures. Based on observations in other countries, elements of a roadmap leading to improved energy efficiency in the Buildings sector could include: (1) a new policy framework; (2) appropriate incentives and penalties; and (3) an infrastructure for monitoring and controlling implementation.

A new policy framework could set ambitious targets for both residential and commercial buildings, covering space heating and other energy consumption in buildings.

- **Space heating.** Following the example of other countries, an ambitious energy efficiency standard for space heating for residential and commercial buildings could be announced in the short term and enforced in the medium term. The investment required to establish an effective energy efficiency standard between 2010 and 2030 is estimated at €14 billion for existing buildings and €4 billion for new buildings.

  In The Netherlands, the “Meer Met Minder” initiative has set a clear ambition for residential buildings through a comprehensive program (Exhibit 12): as a result, 2.4 million Dutch buildings should be using 30 percent less energy by 2020.

Exhibit 12

Meer met Minder

Example from The Netherlands, 2008-2020

Context	▪ Program running since 2008, aiming at reducing energy consumption in 2.4 million existing homes and offices by 30 % by 2020
Who is participating?	▪ Ministers of Environment, Housing and Economic Affairs ▪ Building sector ▪ Energy sector
How does the program work?	▪ Comprehensive package of services aimed at removing barriers for owners, tenants and service providers to make energy saving as attractive as possible ▪ Concrete proposals to achieve energy saving targets, for example tailoring advice for energy-saving measures when owners and users undertake major renovations, developing energy labels reflecting energy efficiency improvement ▪ Targeted promotion and awareness-building campaigns ▪ Creation of *Energie Central* to coordinate the effort ▪ Yearly monitoring of the number of energy-efficient renovations and the total impact on energy consumption in the target groups
Incentives	▪ Low interest rate loans for energy efficiency renovations, repayment of loans through utility bills, amendment of home valuation schemes ▪ Incentive schemes for purchase of energy saving products ▪ Additional subsidy for renewable energy measures such as heat pumps, solar panels and solar heaters

SOURCE: Meer met Minder

In Norway, Building efficiency standards are to be tightened by 25% in 2009.

The public sector (schools, hospitals and public administration offices) could serve as a role model in this area by quickly reaching or even exceeding new energy efficiency standards. In the USA, federal buildings are required to reduce energy consumption by 30 percent by 2010. The EU's Climate Change Action Plan and the EU Directive on Energy End-use Efficiency and Energy Services provide governments in member states with a mandate to encourage such role-modeling from their public sectors.

Funding of energy efficiency measures in public buildings could follow the example of Sweden, where an investment support fund was set up in 2005 to cover the costs of energy efficiency measures for public buildings such as energy mapping and installation of efficient heating, cooling and ventilation systems, and solar panels.

Social housing, too, could be the subject of ambitious high-efficiency construction and renovation programs. In France, a program involving over a thousand social houses aims to create "an urban area of reference" in sustainable development and energy efficiency (Exhibit 13).

- **Applications other than space heating.** An ambitious energy efficiency standard for new equipment and applications other than space heating could be announced in the short term and enforced in the medium term. The estimated total investment between 2010 and 2030 would amount to €6 billion. To give an example, France has decided to ban the use of incandescent light bulbs as early as 2010 – ahead of the European schedule – and has defined strict regulations for heating systems and appliances.

Exhibit 13

Eco-Vallée

Example from Nice, France, 2006

Context	▪ Eco-Vallée is an economic and social project launched in November 2006 aiming to redefine housing schemes in order to get a better social cohesion within the city of Nice ▪ Eco-Vallée also aims to be "an urban area of reference regarding sustainable development and energy efficiency"
How does the program work?	▪ The project consists of the demolition of 485 low-rent (and low energy efficiency) units along with construction of 586 highly energy-efficient houses and rehabilitation of 492 houses to higher energy standards ▪ The rest of the area is devoted to green public spaces and organic agriculture ▪ A public agency is in charge of the management of the project, which will have a total budget of around €177 million

SOURCE: Nice 2018

Appropriate incentives and penalties. Incentives could include lower taxes for individuals who invest in energy efficiency, and also subsidies and other government aid paid out either as a cash advance or a cash reimbursement. These incentives could be restricted to investments with a longer payback time, such as wall insulation; other measures could be made mandatory. Lowering taxes could include reducing the registration tax for houses when new owners undertake major renovations that comply with passive housing standards, or a taxation level that varies depending on the energy efficiency of the building. Specific programs could target owners of rental properties who do not benefit from energy savings, for example by making optimal use of EU-mandated property labelling to raise rental values.

In California, implementing any appropriate energy efficiency measure with a payback time below 7 years is obligatory for new buildings and major renovations (“Title 24” Bill). Incentives are only available for those measures with the longest payback time. In Sweden, building owners who present a program for energy saving measures can claim rebates on their energy tax. The UK’s “Green Landlord Tax” incentivizes landlords to conduct energy efficiency renovations for the houses they rent out by providing tax reductions on relevant labor and materials.

Governments could also ensure that low-interest loans are available to lower the capital investment hurdle and ease access to capital for renovators. In The Netherlands, low-interest loans are available for energy efficiency renovations while in France, a tax rebate of up to €8,000 will be on offer to households for implementing various energy saving measures until 2010.

Policy makers could ensure the effectiveness of such incentives by making them very transparent, for example, through a public nationwide database of all incentives, building on existing initiatives such as the website energiesparen.be. Governments could also link the size of any incentive to the total energy reduction achieved, so directing investment decisions towards thorough renovation or demolition and rebuilding, whichever produces the largest energy gain.

Penalties including housing taxes could be linked to the degree of non-compliance, and could increase after specified deadlines are missed.

An infrastructure for monitoring and controlling implementation. An effective auditing and monitoring system could be implemented and building audits made mandatory. Judging by other countries’ systems, the estimated cost would be €150-200 million a year, financed by the federal or regional governments. In The Netherlands, as part of country’s Technical Assistance Program, energy advisors are mandated to visit commercial buildings to provide customized advice on potential savings.

Energy labeling for a far wider range of residential and commercial appliances could be made mandatory and strictly enforced. In the USA, for example, the “Energy Star” program includes packages aimed at home improvement. In The Netherlands, energy certification and incentives for highly efficient appliances have increased the penetration of such appliances by a factor of four. Similarly, in Japan, the “Top Runner Standard” program has used standard labeling to increase the efficiency and take-up of appliances and equipment.

3. Improving energy efficiency in Road Transportation

This chapter describes the energy efficiency potential in the Road Transportation sector, covering where the sector stands today, what it could achieve by 2030, and possible pathways to greater energy efficiency in Road Transportation.

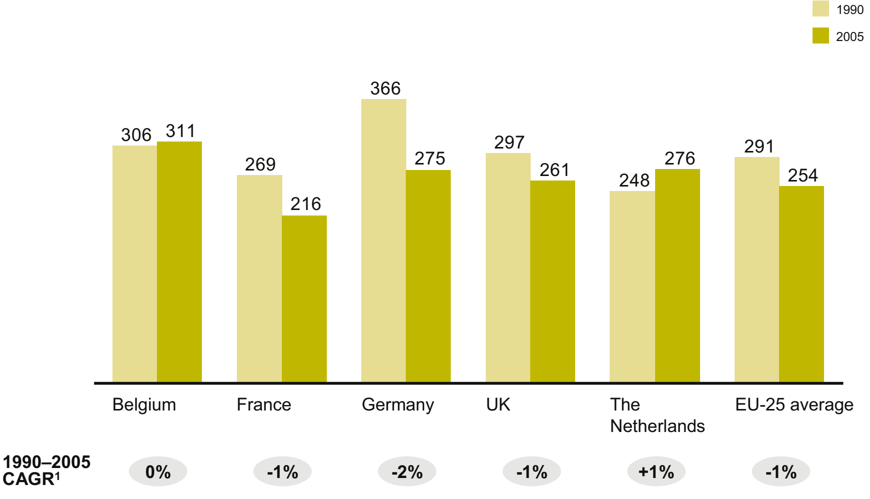
3.1 WHERE BELGIUM STANDS AND WHERE IT IS HEADING

In 2005, primary energy consumption in Road Transportation amounted to 61 million boe. Road Transportation made up 83 percent of total energy consumption in transportation of 74 million boe[24], while aviation, railway, and waterway transport accounted for the remaining 17 percent[25]. Within Road Transportation, 75 percent of energy consumption came from personal cars and other light vehicles. Belgium's vehicle fleet is very energy-efficient: in 2005 its consumption was 5 to 10 percent lower than the EU-15 average. Yet Belgium ranks top of the list of European countries in terms of passenger-kilometers travelled. All in all, fuel consumption per passenger-kilometer in Road Transportation is one of the highest in Europe and not declining (Exhibit 14).

Exhibit 14

Fuel consumption in Road Transportation in selected European countries

Boe/Million passenger-kilometer



1 Compound annual growth rate

SOURCE: NTUA (PRIMES forecast 2007)

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[24] This is based on energy consumption of Belgian vehicles within Belgium – consumption by foreign vehicles within Belgian borders and by Belgian vehicles abroad are considered to cancel each other out.

[25] Aviation accounted for another 9 million boe, while Rail and Inland Navigation used about 2 million boe each. By convention, international marine bunkers are not counted as part of domestic Transport energy usage.

In the BAU scenario, primary energy consumption in Road Transportation is expected to increase from 61 million boe in 2005 to 69 million boe in 2030. This increase would derive mainly from an expansion of the vehicle fleet and longer average distances driven by each vehicle. Ongoing energy efficiency improvements would only partially offset the effects of these developments.

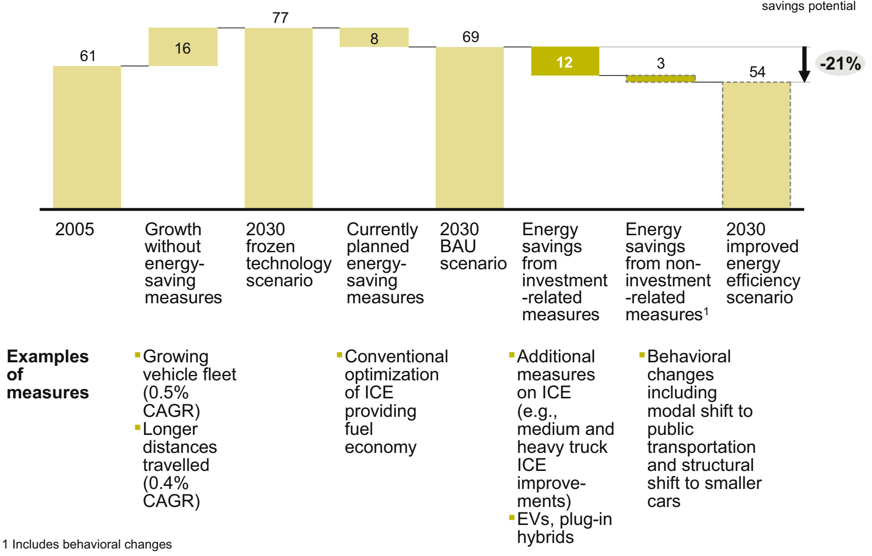
3.2 WHERE BELGIUM COULD BE IN 2030

Our analysis identified a theoretical energy savings potential of 15 million boe from Road Transportation by 2030 (Exhibit 15). Savings from investment-related measures in this scenario amount to 12 million boe, while savings from non-investment-related measures amount to 3 million boe[26]. Better energy efficiency in Road Transportation could be achieved through four categories of improvement measures: conventional vehicle measures, additional vehicle measures, road infrastructure measures, and behavioral measures.

Exhibit 15

Scenarios for energy demand evolution in Road Transportation in Belgium

Primary energy consumption, Boe Millions



1 Includes behavioral changes

SOURCE: NTUA (PRIMES forecast 2007); McKinsey analysis

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[26] Road infrastructure measures have not been included.

Conventional vehicle measures. These consist of technical improvements, such as direct injection and start-stop with regenerative braking (Exhibit 16), applied to traditional internal combustion engines (ICEs) for passenger cars. As these are incremental, fairly low-cost modifications to existing technology involving no new infrastructure, they were included in the BAU scenario. The European Directive on fuel efficiency in Road Transportation has already triggered some of these measures[27], which require concerted efforts from car manufacturers.

Exhibit 16

BAU reduction opportunities in passenger cars

SOURCE: McKinsey Automotive & Assembly Practice

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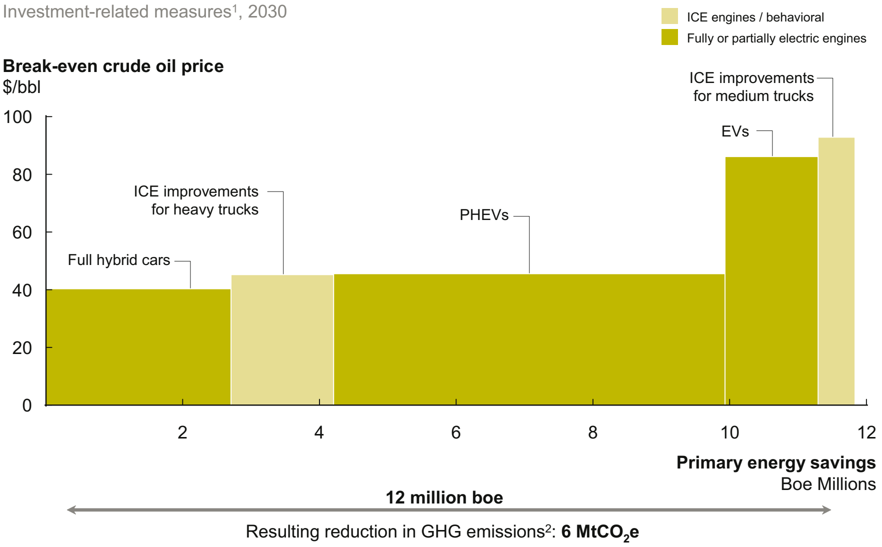
[27] Target of 130g CO_2e/km by 2013 through engine technology improvement, stricter target of 95g/km in 2020.

Additional vehicle measures. These improvements to vehicles typically involve significantly higher technological and market risks. A small share of the energy savings expected from these measures derives from improving ICEs used for commercial and public road transport, but the majority will come from the roll-out of vehicles with electric and hybrid electric motors, referred to collectively as xEVs[28] (Exhibit 17).

Exhibit 17

Theoretical energy savings potential in Road Transportation in Belgium

Investment-related measures[1], 2030



1 The 2030 perspective takes the effect of learning curves on the cost of xEVs into account
2 Includes non-investment-related measures
SOURCE: McKinsey analysis

- **ICEs.** The theoretical energy savings potential from measures improving the energy efficiency of ICEs in vehicles used for commercial and public road transport (mostly trucks and buses) is estimated at 2 million boe. Such measures include power train improvements, such as "mild" hybridization, and non-power train improvements like rolling resistance design and increased aerodynamics efficiency. These improvements are expensive and only improve average fuel economy by about 10 percent: they would be worthwhile for heavy trucks because these trucks travel such long distances, but not for medium-sized trucks, which travel shorter distances. Buses account for only 0.3 percent of all vehicles in Belgium. However, their driving pattern, involving frequent braking and acceleration, means that technical improvements like start-stop systems with regenerative braking and hybridization could improve their energy efficiency substantially. One Belgian bus manufacturer that has developed hybrid electric transit buses already claims that their fuel efficiency is nearly two times higher than that of a standard diesel-powered bus.

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[28] The acronym xEV includes electrified vehicles (EVs), full hybrid electric (HEVs) and plug-in hybrids (PHEVs).

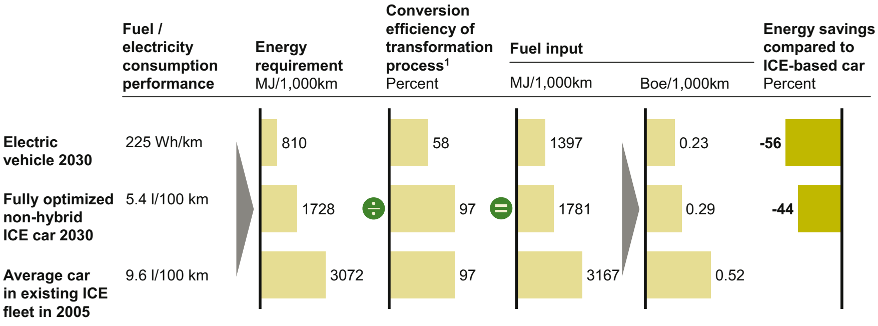
- **xEVs.** The theoretical energy savings potential from adopting vehicles with electric motors is 11.5 million boe, the bulk of which would come from full hybrids[29] and plug-in hybrids. This potential assumes that three quarters of all newly sold cars in 2030 would be xEVs[30]. This fairly high level of penetration is based on the fact that Belgium offers an attractive environment for electrified vehicles. Driving in Belgium generally includes high congestion, short distances, and a lot of commuting around the largest cities, a pattern better suited to electric motors than ICEs, and one which offers plentiful opportunities for recharging.

The cost curve analysis of the energy savings potential of additional vehicle measures shows that implementing ICE improvements for large trucks and deploying full hybrids in the car fleet are "no regret" moves from a societal perspective at an oil price of $62/bbl. However, even though the energy efficiency of electrified vehicles (EVs) is more advantageous from an emissions perspective[31] than personal transportation with ICE vehicles (Exhibit 18), they would only become NPV-positive at a crude oil price of $85/bbl[32]. High battery costs would make the production of an EV about €2,500 more expensive than a comparable ICE car in 2030, even taking the expected decrease in battery prices into account.[33]

Exhibit 18

Comparison of fuel usage efficiency per vehicle type

Energy demand for driving 1,000 km, (real driving, not test cycle)



1 Efficiency of electricity production for electric vehicles, efficiency of crude oil transformation into gasoline/diesel for ICE

SOURCE: McKinsey Automotive & Assembly Practice

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[29] Hybrid electric vehicles (HEVs) have an ICE as their main engine, partly supported/substituted by an electric motor; plug-in hybrid electric vehicles (PHEVs) have an electric motor as their main engine and a small ICE to charge the battery (series) or drive the car (parallel).

[30] The energy savings potential modeled above assumes 20 percent of *new car sales* being EVs, 20 percent being HEVs and 35 percent PHEVs by 2030, with ICEs and xEVs representing 60 percent and 14 percent of the *fleet* by 2020.

[31] Taking this perspective involves analyzing and comparing "well-to-wheel" fuel efficiency and emissions over the life cycle of fuels used for road transportation.

[32] Assuming 15 years of vehicle life time and a 4 percent discount rate for future cash flow projections.

[33] With a retail gasoline price of €1.3/liter and an electricity price of €0.16/kWh, a typical consumer would save €625 p.a. in energy costs with an EV and would break even in 4 years. The analysis excludes potential from EV uptake where the payback would be longer than 4 years, and no discounting of future cash flows in this consumer perspective because, while a consumer would be glad to avoid paying for heavily taxed fossil fuels, he or she would also have high expectations about a quick breakeven on the initial extra cost of €2,500.

The industry as well as consumers would therefore need to be certain of higher crude oil prices in the long term, combined with subsidies and mandatory adoption or other supporting measures for society to capture all the benefits associated with switching to an electric vehicle fleet. These benefits include the effect on GHG emissions: even though ICE improvements for medium-sized trucks and EVs are NPV-negative at a crude oil price of $62/bbl, they would be efficient levers to abate GHG emissions, with an abatement cost below €40/tonne[34].

The evolution of EVs depends on a number of as yet unrealized commercial and technical developments and so remains uncertain. For instance, as well as winning consumer confidence and/or regulatory support, EVs would need to deliver on their technological promises, for example, high battery learning rates and rapid improvements in motors efficiency, while keeping their cost premium over ICEs as low as possible. In addition, from a societal perspective the business case for EVs is particularly sensitive to the efficiency of the electricity generation base.

Road infrastructure measures. A number of road infrastructure measures could improve energy efficiency by reducing distances travelled, improving driving patterns and alleviating congestion, as well as saving lives and improving local air quality. Such measures include introducing changes in traffic management systems, road construction and maintenance, and urban planning. Their energy savings potential has not been assessed in detail in this study.

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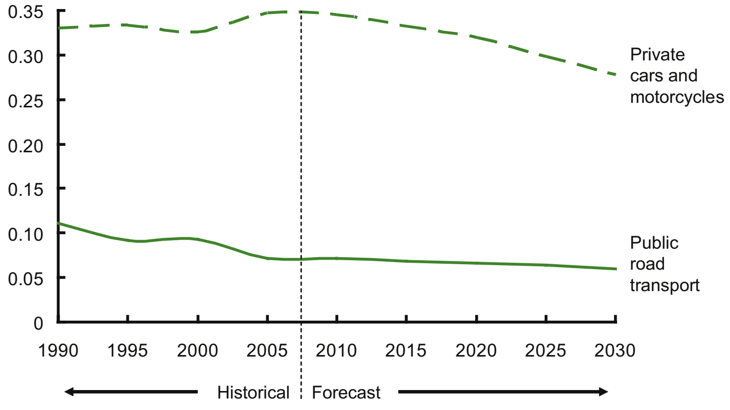
[34] CO_2 abatement levers at a price below €60/t are typically considered necessary to reach the level of GHG concentration that is likely to contain global warming at a global average rise of 2°C.

Behavioral measures. Behavioral changes could contribute 3 million boe to the theoretical potential, though this estimate is highly dependent on the extent of change achieved. One of the biggest levers for improvement would be switching to more energy-efficient public modes of transport. While personal transportation is generally more flexible, easy to use and faster than public transport, its energy intensity per passenger-kilometer is, and will remain for the foreseeable future, much lower than public transportation alternatives (Exhibit 19). Other important behavioral measures for individuals include driving less, for example by carpooling or telecommuting more, choosing smaller or lighter cars, and using cars in a more energy-efficient manner. Behavioral measures for commercial transportation companies include using fewer trucks, for example, by extending the length of trucks or increasing load factors on popular routes, cooperating with other operators on less popular routes, driving each truck less through route optimization, and driving "smarter" – for example, by using vehicles of appropriate capacity, maintaining them properly and making more off-peak deliveries. A shift to the more energy-efficient transport mode of rail for commercial transportation has not been considered since rail options are typically not competitive in small countries.

Exhibit 19

Energy intensity by mode of transport in Belgium

Boe/1,000 passenger-kilometers



SOURCE: NTUA (PRIMES forecast 2007)

Pursuing the full range of energy efficiency measures in Road Transportation would result in a reduction of GHG emissions in Belgium of around 6 $MtCO_2e$. It would also improve air quality and reduce time wasted in traffic. In addition, expanding public transportation and developing infrastructure could create 5,000-10,000 jobs[35], while attracting EV manufacturers to Belgium could create another 5,000-10,000 jobs.

Realizing the identified potential would represent a total investment of about €11 billion between 2010 and 2030, with a payback time of 9 years. Of this total, 10 percent would need to be invested in the first 5 years. At a crude oil price of $62/bbl, 87 percent of the improvement measures would have a positive NPV from a societal perspective.

3.3 PATHWAYS TO ENERGY EFFICIENCY IN ROAD TRANSPORTATION

Initiatives to improve energy efficiency in Road Transportation are already under way. To reach the full potential identified in this report, however, significant additional actions would be required.

Initiatives to date

So far, the most prevalent energy-efficiency measures in this sector have been regulatory changes that stimulate individuals and organizations to use energy-efficient conventional vehicles and to enhance public transportation. Car manufacturers have also started to develop vehicles that are more energy-efficient mostly in reaction to regulatory changes, while companies of all kinds are promoting energy-efficient modes of transportation among their employees.

- The federal government has introduced a subsidy for new cars with emissions below 115-105g CO_2/km (3 to 15 percent of the total car price[36]). Serving as a role model, the federal government has also committed to have 50 percent environment-friendly cars in its fleet.
- The Walloon Region has launched an “eco-bonus/malus” system, offering bonuses for vehicles emitting less than 145 g/km and “maluses” for vehicles emitting more than 196 g/km. It has also abolished tax reliefs for SUVs.
- Both federal and regional authorities have encouraged a shift to more energy-efficient modes of transport by improving the quality of infrastructure (for example, the Regional Express Network or RER, and cycling infrastructure), by decreasing the cost of such shifts, by enhancing convenience (for example, by improving commuter car parks and through the “Iris 2” 2015 plan[37]) and providing better information. For example, initiatives have been introduced for integrating ticket systems between operators, such as the “Jump” ticket available in the Brussels region, the Ubigo Smartcard promoted by STIB, “Billet +” from STIB and SNCB and the recently announced integrated ticket system for all buses, trams and trains in Belgium, to be completed by 2012.

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[35] Estimate based on an extrapolation of employment creation data in road transportation in Europe and in Flanders: *Climate Change and employment: Impact on employment in the European Union-25 of climate change and CO_2 emission reduction measures by 2030*, ETUC, ISTAS, SDA, Syndex, Wuppertal Institute, 2007; *EU Energy and Transport in Figures: Statistical Pocketbook 2005*, European Commission, 2006; *Voorstel van Resolutie tot opmaak van een Groene New Deal voor Vlaanderen*, Groen!, 2009.

[36] Subject to a ceiling.

[37] *Projet de Plan régional des déplacements,* Bruxelles Mobilité/Mobiel Brussel, 2008.

The private sector also contributes to higher energy efficiency through technological innovation and promoting energy-efficient transport for employees:

- Technical measures taken by the automotive industry to make vehicles more energy-efficient have lowered average fuel consumption. As electronic control systems for fuel management and direct-injection diesel cars have become more popular, average fuel consumption has fallen from 8.5 to 7.5 liter gasoline equivalents per 100 kilometer[38] for new European cars over the last 15 years. The gain would have been even higher if consumers had not over the same period shifted to cars with more powerful engines[39]. However, new EU regulations on car emissions[40] corresponding to a maximum gasoline consumption of 5.5 l/100 km in 2015 and 4.0 l/100 km in 2020 are expected to stimulate manufacturers to introduce further technological innovations to lower fuel consumption. Car manufacturers that do not meet the target will face penalties of €1,000-3,000 per car sold.

- Many companies have supported the shift to energy-efficient modes of transportation by offering public transportation and non-motorized forms of transportation to their employees as an alternative. At one large car manufacturer, most employees no longer drive to work by themselves but rely instead on more energy-efficient services such as the company bus network and car pools. Six chemical companies in the port of Antwerp jointly operate an "Industriebus" system with a capacity of up to 1,600 commuters. A professional services firm has a mobility policy that only offers a limited set of company cars and rewards commuting by train[41] (it also encourages "eco-driving" - a more energy-efficient driving style, as discussed below). Finally, a large retailer has launched a "bike to work" program. When the company offered free bikes to interested employees, more than 1,000 people signed up, the majority of whom did not commute by bike before.

- Several companies have launched initiatives to promote eco-driving. For example, in cooperation with the automotive federation FEBIAC, a pilot initiative called "E-Positief" to train 100 eco-drivers was successfully completed. The average fuel reduction after the one-year test period was 7.5 percent. The concept is now being commercialized.

An integrated approach to reach the full potential

To reach the full energy efficiency potential identified for Road Transportation, Belgium would need to follow an integrated approach which could include: (1) encouraging the use of high-efficiency vehicles, while penalizing low-efficiency vehicles; (2) supporting the development of an infrastructure for EVs; (3) increasing the quality and extent and stimulating demand for public transport; and (4) developing a more energy-efficient road environment.

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[38] Figures are for real driving, which is assumed to be 25 percent higher than test values. Corresponds to 202 and 178g CO_2/km, respectively. Gasoline is modeled to on average contain 2,371g CO_2/l. Thus, fuel consumption of "x" liters of gasoline equivalents/100 km corresponds to CO_2 emissions of "23.71x" g/km.

[39] *Worldwide Trends in Energy Use and Efficiency*, International Energy Agency (IEA), 2008, p64.

[40] 130g CO_2e/km in 2015 and 95g CO_2e/km in 2020 (source: European Commission).

[41] Presentaties en verslag symposium 20/11/08. www.mobimix.be/inhoud/presentaties-symposium-mobiliteitsbudget-vs-bedrijfswagen.

Encouraging high-efficiency vehicles, penalizing low-efficiency vehicles. The regulator could encourage consumers and organizations to purchase highly efficient ICEs[42] and hybrids, increasing their respective shares of the total vehicle fleet from 20 percent and around 0 percent respectively in 2010, to 60 percent and 14 percent by 2020, and to 54 percent and 41 percent by 2030. This would represent an incremental cumulative investment of €8.5 billion compared to traditional choices. Highly energy-efficient ICE vehicles should be, on average, 44 percent more efficient than the current average. Highly efficient vehicles could continue to receive a tax rebate in line with their efficiency increase, possibly financed through a tax on the most energy-consuming vehicles.

The regulator could influence the type of vehicles chosen by both individual consumers and companies through incentives and taxes. Influencing companies could be a priority given their high renewal rates, centralized purchasing, their patterns of vehicle use – sometimes with unlimited free fuel supply – and the fact that the current tax treatment of company vehicles encourages inefficient use.

In The Netherlands, vehicle tax is proportional to the energy efficiency of the car. A-rated cars are the most energy-efficient (at least 20 percent more efficient than other cars of similar weight) while G-rated cares are the least efficient (at least 70 percent less efficient than cars of similar weight). A rebate of €1,000 on vehicle tax is available for A-rated cars, and a tax premium of €540 imposed on cars with G-ratings. A further modification of the tax code to reduce the benefits of company cars for both private use and commuting is under discussion.

Supporting the development of an infrastructure for EVs. If Belgium adopted EVs at the same average pace as the rest of the world, they would reach 0.5 percent penetration of the total vehicle fleet by 2020 (less than 100,000 cars), and 4 percent of the total vehicle park by 2030 (250,000 vehicles). EVs alone compared to hybrids could account for 20 percent of the total vehicle park by 2030 if the country were to make a strong commitment to choosing EVs over alternatives. However, Belgium would need to choose which technology to favor soon and make the appropriate infrastructure investments, for example, in a plug-in system or battery swap stations, in order for EVs to be an attractive value proposition compared to existing alternatives by 2012-2015, when electrified vehicles will start to become commercially available on the Belgian market. A total investment of €2 billion would be required, with an additional €0.5 billion to develop the necessary infrastructure.

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[42] Highly efficient ICEs consume on average 5.4l/km or less.

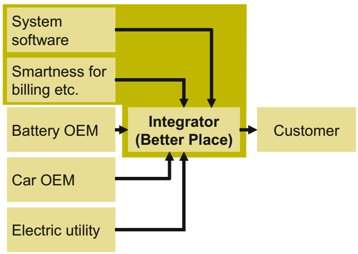
Several national and regional governments have already started to incentivize xEV usage. For instance, Israel and Denmark (Exhibit 20) are strongly reducing or even waiving their comparatively high car registration taxes for EVs. The company Better Place is to build an infrastructure of up to 500,000 charge points and 100 battery swap stations in Israel by 2011. In Portugal, the government has taken responsibility for developing the charging stations infrastructure. Spain has a target of 1 million EVs by 2014 as part of a government plan to save energy. Denmark, Portugal, Australia, Canada and California have also made ambitious xEV plans. Other countries, such as Germany and Italy, are introducing small-scale pilots.

Exhibit 20

Developing an electric vehicles solution

Example from Denmark

Better Place concept



Integrator

- Integrates all components
- Maintains customer relationship
- Owns/finances batteries, charge points, and swap stations
- Provides services (timing of charging, swap management, and battery monitoring)
- Is paid a per km subscription fee
- Gets potentially full surplus value of lower TCO (or shares with customer)

Denmark case study: Roles and incentive structure

Better Place Denmark

- Set up by Better Place Plc., DONG (electric utility) and financial investors
- DONG to invest "8 digit" € amount
- Target: have 20% of car park electrified by 2020
- Exemption from new car registration tax (normally 105-180% of car value) for EVs crucial incentive

Electric utility

- Surplus electricity from unused wind power capacity exported at low prices
- EVs ideal users of surplus electricity and good for storage / load-balancing
- Even with 25% of car park electrified, 70% of EV demand coverable with this surplus

Car OEM

- Renault-Nissan first automaker to join, others invited
- Will offer mid-segment cars with performance and maximum speed like ICE cars from 2011

SOURCE: DONG Energy; McKinsey analysis

Developing public transportation. Given that public transport outperforms even the most energy-efficient private vehicle on energy efficiency, Belgium could redesign public transportation infrastructure across all the regions. Long lead times for implementing such improvements means that swift action is needed. Incentives for using public transport could be coupled with penalties for using personal transport, for example, congestion charges or restricted parking.

The public authorities could guide consumers and businesses to choose more energy-efficient modes of transportation in particular by developing a frequent, reliable and far-reaching offer of road and rail-based public transport. In some cases, extending public transport may be more about offering a service for "the last mile" than improving main routes. If publicly-funded transport solutions do not make economic sense, transport operators could cooperate with third parties to offer alternatives to owning a car such as shared cars, (as in the Cambio system), shared cabs, taxis, carpooling, and bike rentals. The Netherlands has created a program targeted at companies offering company cars that gives employees mobility credits that they can freely spend on car or public transportation.

Increasing the supply of good public transportation would have to be accompanied by measures making passenger car traffic in inner cities even less attractive: Stockholm's experience shows that extending public transportation by itself has little influence on car travel. Only when car travel becomes more expensive in terms of money or time do people use public transport more[43].

Developing an energy-efficient road environment. Belgium could implement "smart traffic management measures" especially in congested areas. These could consist of a mix of ICT-based systems, such as smart lanes, and measures introduced by individual organizations, for example, spreading vehicle use during the day. Forms of urban development that reduce the need for transportation, for instance, combining residential and commercial units or adopting higher housing unit densities, could also be encouraged.

There are several examples of policy makers putting in place measures to improve the road environment. Several cities have introduced charges for using cars in congested areas to dissuade people from driving. In London, 3 years after such a scheme was introduced in 2003, the number of cars in the inner city was down by 20 percent; yet the long-term impact on congestion is still being debated. Existing charging systems use Electronic Fee/Toll Collection (EFC/ETC), but the charges are static so they cannot adjust to the traffic situation on the ground. The European Galileo navigation satellite service system will be able to manage congestion better with dynamic charging, but will not be operational until 2013 at the earliest. In the Netherlands, a pilot project showed that carrying out deliveries to stores outside rush hours limited congestion and reduced the number of trucks required by 30 percent. Night deliveries are allowed in the Netherlands, provided that trucks' noise levels stay below certain limits.

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[43] *Facts and Results from the Stockholm Trial*, Congestion Charge Secretariat, City of Stockholm, December 2006, p4.

4. Improving energy efficiency in Industry

This chapter describes the energy efficiency potential in the Industry sector, covering where the sector stands today, what it could achieve by 2030, and possible pathways to greater energy efficiency in Industry.

4.1 WHERE BELGIUM STANDS AND WHERE IT IS HEADING

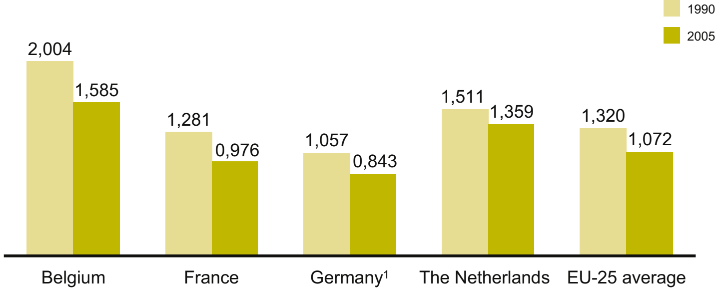
In 2005, Industry accounted for about 144 million boe or 39 percent of Belgium's total primary energy consumption. This figure includes all primary energy used for industrial activities except for energy products used as raw materials in producing other products (for example, coking coal used in a blast furnace to produce steel). Energy consumed by industrial buildings, for HVAC, lighting, and support functions, is estimated to be only 3.5 percent of total Industry consumption[44, 45].

The Belgian economy has a high share of energy-intensive industries (Exhibit 21) and three sectors – Chemicals, Iron and Steel, and Petroleum and Gas – account for the majority of Industry's energy consumption (Exhibit 22)[46].

Exhibit 21

Energy intensity of industries in selected European countries

Boe/€ Millions of Industry Gross Value Add (GVA)



	Belgium	France	Germany[1]	The Netherlands	EU-25 average
1990–2005 CAGR[2] Percent	-2	-2	-2	-1	-1
Energy-intensive sectors' share of industry GVA[3] Percent	9.0	5.4	8.6	9.7	8.0

1 For Germany, 1995 has been used as the base because of the closing down of factories after reunification
2 Compound annual growth rate
3 The definition of energy-intensive industries by NTUA (PRIMES forecast 2007): Chemicals; Forest products; Glass; Metals & Metal products; Mining & quarrying; Petroleum Refining; Steel

SOURCE: EuroStat, NTUA (PRIMES forecast 2007); Global Insight

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[44] Consumption estimates for industrial buildings (HVAC, lighting, and support functions) of 5.1 million boe in 2005 and 4.7 million boe in 2030 based on US data.

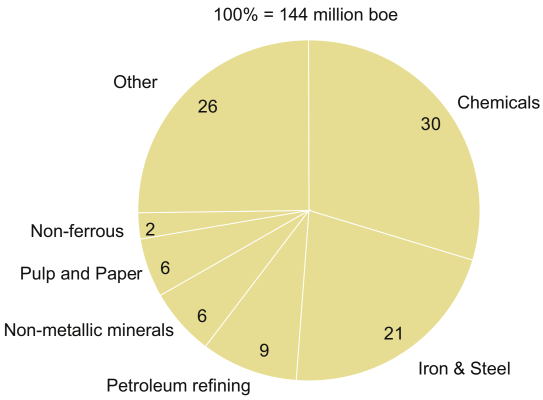
[45] While consumption for heating/cooling of buildings is included in the baseline consumption data, the improvement potential from this source has not been assessed as it would be negligible. The type of energy-saving measures are the same as those described in the Buildings chapter.

[46] For the purpose of this study, all further analyses assume that the activity mix and composition of energy-intensive industries remains the same as in the BAU scenario.

Exhibit 22

Breakdown of primary energy consumption by industry in Belgium

Percent, 2005



SOURCE: Eurostat

In the BAU scenario, Industry's primary energy consumption is expected to peak at 149 million boe in 2010 before dropping to 133 million boe by 2030. This fall reflects companies' ongoing efforts to improve their energy efficiency and also a change in Belgian's power generation mix.

[43] *Facts and Results from the Stockholm Trial*, Congestion Charge Secretariat, City of Stockholm, December 2006, p4.

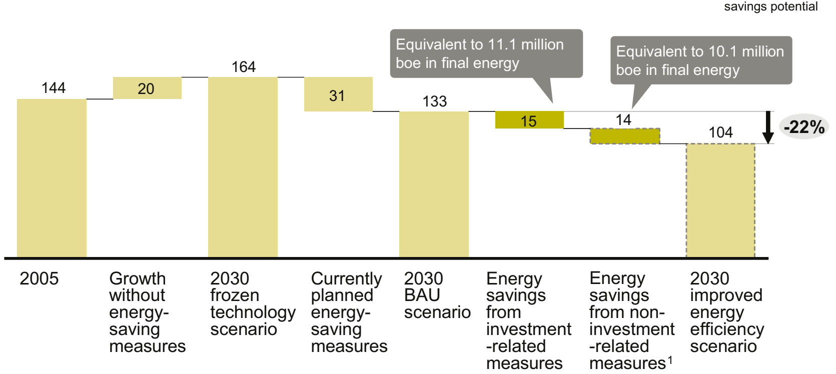
4.2 WHERE BELGIUM COULD BE IN 2030

Our analysis has identified a theoretical energy savings potential of 29 million boe from Industry by 2030. This would reduce Industry's primary energy consumption to a level 20 percent lower than consumption in 2005 and 22 percent lower than in the 2030 BAU scenario. Fifteen million boe of this savings potential comes from investment-related measures, and 14 million boe from behavioral and non-investment related measures (Exhibit 23); final energy savings amount to 11.1 million boe and 10.1 million boe respectively.

Exhibit 23

Scenarios for energy demand evolution in Industry in Belgium

Primary energy consumption, Boe Millions



Equivalent to 11.1 million boe in final energy

Equivalent to 10.1 million boe in final energy

Examples of measures	Growth in production volumes	Higher penetration of energy efficiency measures, incl. capital-intensive measures	Higher throughput Lean transformation Energy efficiency optimization mindset and implementation of energy management system

1 Includes behavioral changes

SOURCE: NTUA (PRIMES forecast 2007); McKinsey analysis

Investment-related measures

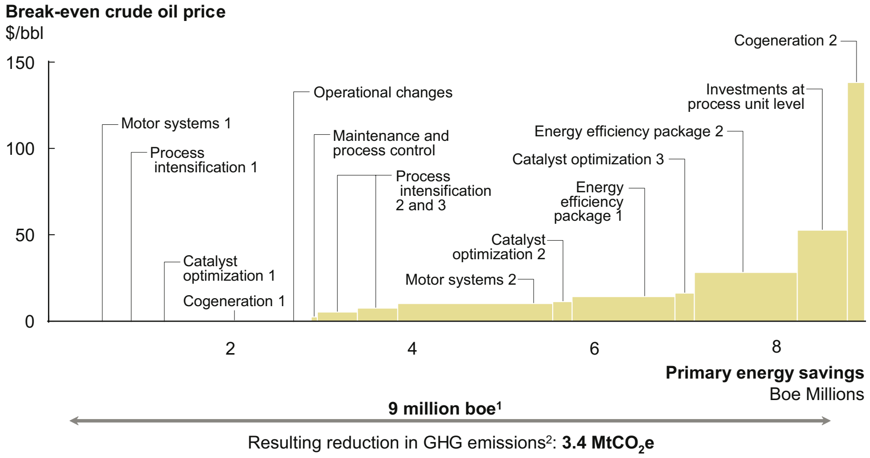
The analysis identified industrial measures that could save 15 million boe of primary energy in 2030 but would require investments of €5 billion between 2010 and 2030, with an average payback time of 4 years. The theoretical savings potential was calculated for the Chemicals, Iron and Steel, and Petroleum and Gas industries (Exhibit 24), and then extrapolated for the other industrial sectors. At an oil price of $62/bbl, 99 percent of the investment-related savings potential would be NPV-positive. The main categories of improvement measures are:

- **Improving waste heat recovery,** by installing or retrofitting co-generation units to integrate power and heat generation across industrial sites. In the three largest energy-consuming sectors alone, combined heat-power installations and retrofits could save up to 2 million boe in primary energy. Waste heat recovery from air compressors, for example, can be used for space and water heating, industrial process heating, makeup air[47] and water preheating, industrial drying and cleaning processes, and preheating air in oil burners. Certain industrial processes are particularly suitable for waste heat recovery, for example clinker burning in the cement industry, where flue gas exhaust streams can also be used for electricity generation. Heat recovery systems have a lifetime of about 20 years. With much of this equipment originally installed during the oil crisis in the early seventies and replaced only once since then, a large number of replacements may be required before 2020.

Exhibit 24

Theoretical energy savings potential in the 3 most energy-consuming industries in Belgium

Investment-related measures, 2030



1 These numbers only reflect the investment-related potential from the 3 most energy-consuming sectors; the total investment-related energy savings potential for Industry has been extrapolated from this basis

2 Includes non-investment-related measures

SOURCE: McKinsey analysis

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[47] Makeup or compensating air is external air that is introduced to replace air that is expelled through ventilation or combustion processes.

- **Installing more energy-efficient equipment,** such as more efficient transformers, motors, fans, and pumps. New installations typically have a payback time of less than 2 years. The savings potential results from improved equipment design, using equipment of a size more appropriate to its intended function, and using variable speed drives to match equipment speeds with actual load requirements more efficiently. In the chemicals industry alone, improved motor systems could result in up to 1.8 million boe in savings. This type of equipment has a typical lifetime of 5 to 10 years, creating an opportunity to replace gradually most aging items with more efficient models over the next 10 years.

- **Enhancing maintenance to keep equipment in optimal condition.** Better maintenance requires little or no upfront investment and brings the additional benefits of decreasing downtimes and extending equipment lifetimes. For example, preventive maintenance and more prudent operation make boilers more reliable[48]; more consistent inspection and repair of the bearings and seals in pumps reduces their energy consumption. In petroleum refining operations, where pumps typically account for about half of all the electricity use, the benefits of paying more attention to maintenance are considerable. Such measures have an almost immediate payback.

- **Improving process control** through better control systems and sensor technology will have a positive effect not only on energy consumption but also on maintenance costs, equipment downtime and processing time in nearly every industrial process. Examples include the sintering process in steel production where up to 2 percent efficiency improvements could be achieved, and automated boiler load management in petroleum refineries. Improving process control can start delivering energy savings after only about 6 months of study and implementation.

- **Balancing production and consumption of utilities.** Electricity and steam consumption can be shaved. For example, peaks can be avoided by extending utilization times and coordinating utilities consumption forecasts, not only on a weekly or monthly basis but also daily and even hourly. A better coordination of the shutdown of utility-consuming units shaves consumption too and reduces expensive start-up costs. These measures, too, will start delivering energy savings results after about 6 months of study and implementation.

- **Adopting a series of industry-specific levers.** In addition to these general measures, each sector and company faces a set of industry- and company-specific opportunities for improving energy efficiency in their processes. These are often harder to identify and realize as they require thorough knowledge of each process and company. In addition, some process-specific measures, such as improving ethylene cracking in the chemicals industry, and integrating the preparation of coke with iron ore reduction in the iron and steel sector, would require considerable R&D and investments. Because customized measures such as these are unlikely to yield much impact by 2030 they have not been included in the theoretical energy savings potential.

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[48] For example, increasing reliability from 93 percent to 98 percent (eliminating 2 percent of total calendar time going towards unplanned stops and 3 percent for planned maintenance).

Non-investment-related measures

Observations and analyses in over 100 production sites across Europe, including sites in Belgium, indicate that, on average, practices dedicated to improving energy efficiency that require no incremental spending could deliver savings of 12 percent or 17.5 million boe of primary energy consumption compared to the 2005 baseline. This potential can be achieved by improving throughput, applying lean practices, and changing the mindsets and behaviors of management teams and workforces. Up to 20 percent of this potential would be realized in the BAU scenario, leaving about 14 million boe of primary energy to be captured through additional changes in operating practices and behaviors.

- **Higher throughputs** could result in energy efficiency gains of about 5 percent over 2005. Other lean practices such as yield management and quality improvements could bring an additional 2 percent in energy savings. These practices themselves may require investments, for example, in installing larger reactors, but capturing the energy efficiency benefits such investments offer would have no incremental impact on the level of investment entailed.

- **Changes in practices**, mindsets and behaviors backed by a better energy management infrastructure could reduce energy waste and bring an additional efficiency gain over 2005 of 5 percent. Such changes would depend on significantly improving awareness of energy costs and current energy losses across the industrial sector, developing an energy conservation mentality (“turn it off if it isn’t needed”), and designing energy-saving shop floor procedures that are standardized, visible and helpful for operators. A basic set of measures to instill energy efficiency discipline would include developing specific energy efficiency KPIs and cascading them across the organization to the shop floor; addressing energy efficiency during site leaders’ meetings, and holding regular energy performance discussions on the shop floor.

The impact of efficiency gains on production costs would be significant: at an oil price of $62/bbl, the share of energy in the total cost of final products is 10 to 20 percent on average in energy-intensive sectors[49]. This implies that a 20 percent reduction of energy consumption from 2005 levels could lead to a 2 to 4 percent reduction of final costs. Achieving the full energy efficiency potential would reduce GHG emissions by 11 $MtCO_2e$ compared to the BAU scenario. This contribution would be critical in enabling Belgium to meet current and future GHG reduction targets.

[49] McKinsey & Company, Operations Practice.

4.3 PATHWAYS TO ENERGY EFFICIENCY IN INDUSTRY

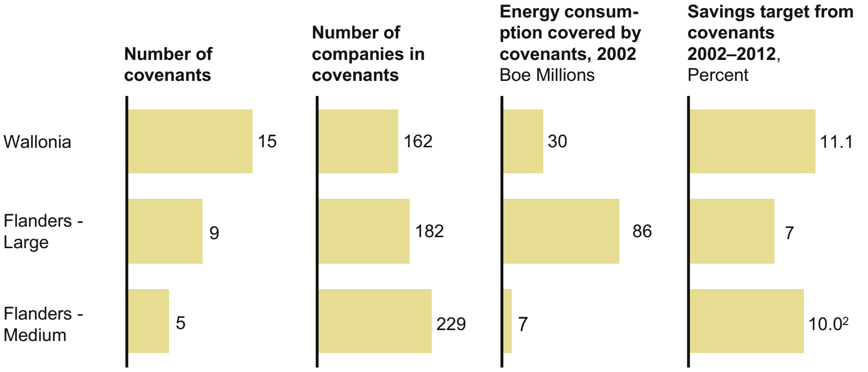
Initiatives to date

In Belgium, energy efficiency measures in the industrial sector have so far mainly taken the form of covenants, or voluntary agreements, between regional governments and industry. In return for making such a covenant, industries gain three types of support from regional governments: protection from further CO_2 and energy efficiency-related regulation, priority for fiscal support to improve energy efficiency, and positive publicity.

Between 2000 and 2004, 162 Walloon and 411 Flemish companies signed a covenant with their respective regional government. All Petroleum and Steel companies and most large companies in Chemicals and the other industrial sectors – together representing about 90 percent of the nation's industrial energy consumption – have made such covenants (Exhibit 25). These covenants are expected to deliver an energy efficiency improvement of 8.8 percent between 2002 and 2012: 11.1 percent between 2002 and 2012 for Wallonia, 7.4 percent between 2002 and 2012 for large Flemish companies, and 10 percent between 2005 and 2012 for medium-sized Flemish companies.

Exhibit 25

Setup and objective of industry covenants in Belgium



1 This is the expected saving based on companies' first round energy plans. New and updated energy plans are currently being aggregated and may result in a different expected savings level.
2 Covenant started in 2005; target period 2007-2012

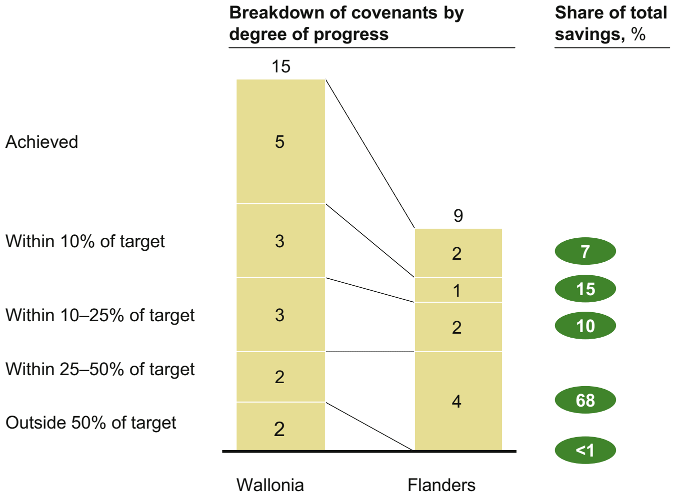
SOURCE: 2007-08 annual covenant reports

The 2007 covenant status updates indicate that energy efficiency savings of 6.7 percent – three quarters of the 2012 target – have already been captured. Closer investigation of the covenants for large players shows that seven out of 24 sectors, representing 7 percent of the total savings target, have already reached their 2012 savings target; another nine sectors, representing 25 percent of the total savings target, are within 25 percent of the savings target (Exhibit 26).

Exhibit 26

Progress of covenants towards the saving targets

Large consumers, Wallonia & Flanders, 2007



SOURCE: 2007-08 annual covenant reports

- **In Wallonia,** 162 companies participate via their sector federation in one of 15 so-called Branch Agreements. These covenants cover 30 million boe, which corresponds to about 80 percent of total regional industrial energy consumption, or 21 percent of national consumption.
- **In Flanders,** 182 companies with an annual primary energy consumption of at least 0.5 petajoule (PJ) participate in the Benchmark Covenant, and another 229 companies with an annual consumption between 0.1 and 0.5 PJ participate in the Audit Covenant. The Benchmark Covenant and Audit Covenants cover 93 million boe and 7 million boe respectively, corresponding to about 80 percent and 9 percent of total regional industrial energy consumption, or 65 percent and 5 percent of the overall energy consumption in Belgium.
- **The Brussels-Capital region** has opted for a voluntary energy management system and labeling program called “Eco-dynamic Enterprise”. This also covers the services sector, as industrial activity in the Brussels region is limited.

An integrated approach to reach the full potential

Reaching the full potential identified in the improved energy efficiency scenario for the industrial sector would depend on implementing an integrated set of measures. Elements of a roadmap leading to improved energy efficiency in Industry could include: (1) a renewed commitment to energy efficiency from Industry; (2) an extended scope; (3) support for SMEs; and (4) the development of transversal programs.

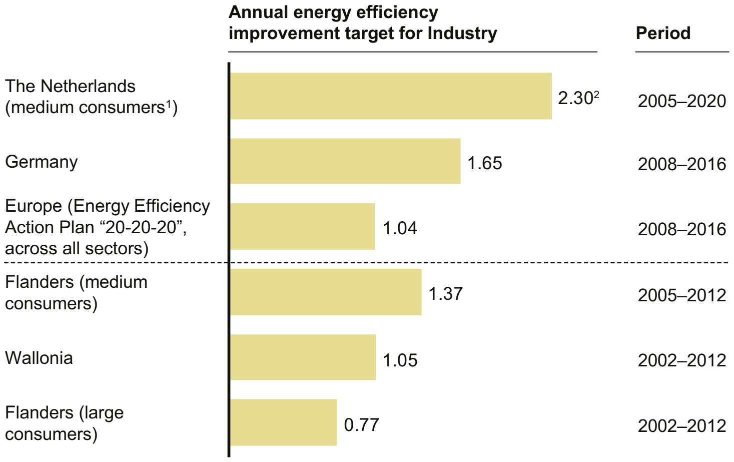
Renewed commitment from the industry. Continued commitment from industry could be achieved through new covenants. These could include ambitious targets covering the entire industrial sector and taking the form of fixed annual improvements informed by the identified energy savings potential. A sufficiently long period for achieving these targets (2030 for example) would allow companies to adopt a long-term investment perspective.

In The Netherlands, with an average energy intensity in its industrial sector that is similar to Belgium's[50], the energy efficiency improvement target for medium-sized energy users over the 2005-2030 period translates into a 2.3 percent annual improvement (Exhibit 27). In 2007, Process Efficiency and Energy Efficient Product Development accounted respectively for 52 percent and 29 percent of the overall Dutch energy efficiency improvement over 2006. The remaining 19 percent came from using renewable energy, a third compliance mechanism under the Dutch covenants, which reduces CO$_2$ emissions but not energy consumption itself.

Exhibit 27

Energy efficiency improvement targets by region

Percentage



1 Discussions in final round for large consumers to leave their Benchmark Covenant and join the Long Term Agreement (LTA) for medium consumers
2 The 2% that is generally found in LTA communication is the annual share calculated as 30% divided by 15 years, not the actual reduction that is required to arrive at the full 30% after 15 years. The LTA target allows companies to bring renewable energy into account.

SOURCE: National Energy Efficiency Plans

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[50] Within the energy-intensive industry segment, structural differences exist.

Process Efficiency focuses on own operations, and implementing a formal energy management system is a central and compulsory condition accepted by the industrial signatories of Dutch covenants. “Allowable” improvements can be the result of either dedicated energy management measures or operational changes such as throughput increases.

Dutch companies are allowed to find energy efficiency improvements not just within their own operations but along the entire value chain, by working more closely with their suppliers and clients on energy efficiency. This value chain approach, known as Energy Efficient Product Development (EEPD), includes improvement strategies ranging from “cradle-to-cradle” optimization[51] to optimized transportation and distribution. In Belgium, any new commitment from Industry that allows such a value chain perspective should be carefully designed to avoid double-counting: while one party in the value chain may obtain the recognition or credits attributed by the covenant for greater efficiency, other parties further down the chain would need to benefit in different ways, for example by capturing the financial value of using fewer resources in production.

A fixed annual improvement target has several advantages over an international benchmark. Like a benchmark, it could take into consideration an industry’s starting position if it is informed by the identified energy savings potential. It can, however, go further than a benchmark and stimulate continuous improvement, possibly beyond what the current state of commercialized technology and equipment can achieve. Another advantage is that it would be simpler to implement and easier to follow up than targets based on international benchmarks. Fixed annual targets have been adopted by most comparable countries, including the UK and Germany. In The Netherlands, large industrial consumers are entering the final round of discussions on relinquishing their benchmark covenants in favor of fixed annual targets in so-called Long Term Agreements (LTAs).

Extended scope. Currently, 10 percent of total Industry energy consumption is outside the scope of existing covenants. This corresponds to the consumption of more than 50,000 companies, mainly SMEs. Apart from committing themselves to an energy efficiency covenant, the following options could also help these companies to improve their energy efficiency:

- **Full value chain optimization.** Larger companies with expertise and experience could be encouraged to support smaller companies in their efforts to improve energy efficiency. The benefits could then be shared.

- **Cradle-to-cradle production,** as in the EEPD approach described earlier. The EU’s Eco-Efficiency Initiative has outlined a potential path of targets leading to cradle-to-cradle efficiency, with a reduction of resource use of 25 percent in 2010, 75 percent in 2030 (“Factor 4”), and 90 percent in 2050 (“Factor 10”). Countries including Germany, Austria, Italy, Japan and Australia already considered eco-efficiency goals at the national level.

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[51] “Cradle-to-cradle” optimization refers to the development of products and processes that optimize energy consumption over the entire lifetime of a product or process, from using fewer, low-impact materials and resources in the production process all the way through to efficient disposal.

- **Industrial clustering** aimed at improving materials and energy efficiency. National programs encouraging clusters are familiar in several Asian countries with strong central governments and fast-growing economies. Other types of countries, such as The Netherlands and Denmark, also have an extensive track record in promoting this form of industrial ecology. In Belgium, incremental energy efficiency savings from clustering may be harder to capture because there are no large greenfield sites. Belgium does have sustainability subsidies for new and existing industrial estates, but in Flanders, for example, they are intended to stimulate the use of renewable energy and are not coupled with any energy efficiency requirements.

Support for SMEs. An energy efficiency program for SMEs would ideally build on existing support systems. It could provide additional incentives, especially financial support for energy-efficient equipment and systems, as well as consolidate, expand and (co-) finance audit and consulting services.

- **Incentives** could take the form of tax rebates, such as those that exist in The Netherlands, subsidies similar to those made available in Austria and Canada, zero- or low-interest loans like those available in Germany and the UK, or the kind of credit guarantees offered by the Dutch government.

- **Audits and consulting services** could be supported by subsidies, which is the case in Germany, Austria, Denmark, Ireland and Finland. Germany provides subsidies of up to 80 percent on first-time energy efficiency audits, and up to 60 percent on detailed audits. The German government also offers a single point of contact for SMEs to get information about efficiency measures and subsidies. Usually, audits are voluntary for SMEs, although in Germany and Austria they are a condition of eligibility for low-interest loans for energy efficiency investments. In addition to appropriate incentives, a vast supply of qualified auditors and consultants is required for a widespread uptake of energy audits. Germany and Austria provide formal training and certification for their auditors and consultant pool to encourage its expansion.

Development of transversal programs. These information-based programs aim to guide companies towards the most energy-efficient solutions and help them with the implementation, therefore reducing their reliance on qualified engineering and procurement staff. Examples include clear equipment labeling and other programs that standardize or organize information.

- The EU's voluntary Motor Efficiency Labeling Scheme demonstrates that transparent information about the energy efficiency performance of industrial equipment can stimulate its uptake. Because products are typically traded internationally, new labeling standards need to be agreed at European rather than country level. Labeling programs such as "Energy Star"[52] for office equipment, for example, could be expanded to include motor systems and furnaces.

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[52] Energy Star is an EU program that allows manufacturers to use the Energy Star logo on products that comply with a set of energy efficiency requirements. It also lists those products in a publicly accessible database to assist businesses in the selection of energy-efficient equipment.

- The UK has developed a broad set of information aids for different types of industrial energy stakeholders. They can access a rich set of information including energy audit reports, sources of funding, and specialist advice via different channels (internet, phone hotline and face-to-face advice). The comprehensive set of information made available by France's Gimélec (the sector association of electrical equipment and control systems manufacturers) or the Lawrence Berkeley National Laboratory in the US (an entity of the US Department of Energy) demonstrates that both industry and academia can play an important role in the aggregation and dissemination of technical knowhow.

- Access to information is not always sufficient to guide companies in implementing energy efficiency measures successfully. Sector organizations could therefore develop "learning networks", through which companies can learn with and from their peers. Possible models include Ireland's Large Industry Energy Network and VOKA's WEAS program in Flanders.

Concluding remarks

BUILDING AWARENESS THROUGH EDUCATION

The experience of other countries shows that being able to identify and capture energy efficiency opportunities depends on developing an unprecedented awareness of energy efficiency among individuals, companies and authorities.

In the short term, a good deal of "instant" awareness could be generated by information campaigns tailored to individuals and companies. In Belgium, the regional and federal governments have already developed such campaigns, especially for the Buildings sector.

However, the best means of creating a "continuous improvement" mindset would be to integrate energy efficiency and other energy issues into every educational curriculum, whether vocational, technical, general or higher education, and so build energy-saving capabilities among the next generation of employees. Companies and non-profit organizations could participate in developing and delivering some elements of the curriculum. Students in vocational training programs, for example, could participate, real-time, in implementing a company's energy management system.

THE NEED FOR AN INTEGRATED LONG-TERM PROGRAM

The various measures that together provide significant potential energy efficiency savings come at different individual costs. Our analysis shows that a comprehensive, long-term program ensuring that complementary measures are adopted as a package is likely to be preferable to a fragmented approach that cherry-picks the easiest or most profitable measures. Such an integrated approach is essential if Belgium is to reach Europe's "20-20-20" goals. A coordinated plan would reduce duplication of effort, and help avoid allocating funds disproportionately to one or more measures over time. Communicating such a coherent energy policy roadmap clearly and early on would create a stable investment climate.

An energy policy roadmap for the next 10 to 20 years would start from a clear vision, have phased objectives and milestones, and include a set of mechanisms for implementing identified energy efficiency opportunities. This set of mechanisms would combine providing information and incentives, monitoring progress and enforcing penalties. While the mechanisms should be flexible enough to respond to particular economic, technological and environmental developments, they should also be sufficiently clear and stable in principle to attract investors. From a societal perspective, the savings generated by the cheapest measures could be used – in part or in total – to pay for the more expensive levers; without such a contribution the latter might be difficult to implement.

We hope the analysis provided in this report will serve as a useful starting point for corporate leaders, policy makers, and other decision makers as they discuss how to improve energy efficiency in Belgium.

List of levers

This is the complete list of measures analyzed for their potential for improving Belgium's energy efficiency; details are provided in the right-hand column. The cost curves in exhibits 10, 17, and 24 show their relative potential impact on the total energy savings potential identified.

BUILDINGS

Residential

Electronics: Consumer	Purchase high efficiency consumer electronics (e.g., PC, TV, VCR/ DVD, home audio, set-top box, external power, charging supplies) instead of standard items
Appliances	When refrigerator/ freezer, washer/ dryer, dishwasher, and fan reach the end of their lifecycle, replace with high efficiency model
Lighting: Switch CFLs to LEDs	Replace CFLs with LEDs when technology becomes viable
HVAC: Retrofit gas/oil heating	When current gas/ oil furnaces or boilers reach the end of their lifecycle, replace with the highest efficiency model, with AFUE (annual fuel utilization efficiency) rating above 95
HVAC: Retrofit electric resistance heating to electric heat pump	When current gas/ oil furnaces or boilers reach the end of their lifecycle, replace electric furnace with high efficiency electric heat pump
HVAC: Retrofit maintenance	Reduce energy consumption from HVAC and AC through improved maintenance
Water heating: Replacement of electric	• When existing standard gas water heaters reach the end of their lifecycle, replace with solar water heaters, or with tankless/ condensing models • When existing electric water heaters reach the end of their lifecycle, replace with solar water heaters, or with tankless/ condensing models
Building envelope: Retrofit package 1	• Improve building air tightness by sealing baseboards and other areas of air leakage • Weather strip doors and windows • Insulate attic and wall cavities • Add basic mechanical ventilation system to ensure air quality
Building envelope: Retrofit package 2	• Retrofit to "passive" standard in conjunction with regular building renovations • Install high efficiency windows and doors; increase outer wall, roof, and basement ceiling insulation; mechanical ventilation with heat recovery, basic passive solar principles
New buildings: Efficiency package	Achieve energy consumption levels comparable to passive housing • Reduce demand for energy consumption through improved building design and orientation • Improve building insulation and air tightness; improve material and construction of walls, roof, floor and windows • Ensure usage of high efficiency HVAC and water heating systems

Commercial

Appliances	For food service/ grocery, use high efficiency refrigerators/ freezers
Electronics: Office	Use high efficiency office electronics (e.g., printer, copier, fax) instead of standard items
Lighting: Switch CFLs to LEDs	Replace CFLs with LEDs when technology becomes viable
Lighting: New building controls	New buildings – install lighting control systems (dimmable ballasts, photo-sensors to optimize light for occupants in room)
Lighting: T12 to T8/T5 standard	Replace inefficient T12s/ T8s with new super T8s and T5s
Lighting: Retrofit controls	Retrofit – install lighting control systems
HVAC: Retrofit	When HVAC system reach the end of their lifecycle, install highest efficiency system
HVAC: Retrofit controls	Improve HVAC control systems to adjust for building occupancy and minimize re-cooling of air
Water heating: Replacement of electric	• When existing standard gas water heaters reach the end of their lifecycle, replace with tankless gas, condensing gas, or solar water heater • When existing electric water heaters reach the end of their lifecycle, replace with tankless gas, condensing gas, or solar water heater
Building envelope: Retrofit	• Retrofit to "passive" standard in conjunction with regular building renovations • Improve building airtightness by sealing baseboards and other areas of air leakage • Weather strip doors and windows • Install high efficiency windows and doors; increase outer wall, roof, and basement ceiling insulation; mechanical ventilation with heat recovery, basic passive solar principles
New buildings: Efficiency package	Achieve energy consumption levels comparable to passive housing • Reduce demand for energy consumption through improved building design and orientation • Improve building insulation and airtightness; improve material and construction of walls, roof, floor and windows • Ensure usage of high efficiency HVAC and water heating systems

ROAD TRANSPORTATION

Full hybrid cars	An electrical drive system is packaged in parallel to the ICE drive system and is calibrated to run when conditions best suit electrical driving. Full hybrid battery is charged by the drive cycle of the vehicle (e.g., through regenerative breaking)
ICE improvements for heavy trucks	• Reduce rolling resistance • Improve aerodynamics • Make conventional ICE improvements such as mild hybrid
PHEVs	Full hybrids that can be recharged both by the vehicle-driving cycle and by external sources, enabling the vehicle to run more frequently on electrical power
EVs	EVs are powered by an electric motor that receives power, via a controller, from a battery of significant capacity
ICE improvements for medium trucks	• Reduce rolling resistance • Improve aerodynamics • Make conventional ICE improvements such as mild hybrid

INDUSTRY

Cogeneration 1 and 2	Use energy lost in power production to generate heat for processes. This increases system efficiency and decreases the amount of fuel needed for power generation.
Energy efficiency packages 1 and 2	Make annual improvements in direct energy efficiency above reference case through the following levers: better preventive maintenance, improved process flow, motor systems, new efficient burners, pumping systems, capacity utilization management, heat recovery, sinter plant heat recovery, coal moisture control, pulverized coal injection
Motor systems 1 and 2	Introduce energy saving measures in motor systems like adjustable speed drive, more energy-efficient motors, and mechanical system optimization
Process intensification 1, 2, and 3	Intensify processes to gain annual energy savings. Improvement levers include continuous processes, improved process control, preventive maintenance, more efficient burners and heaters and logistical improvements
Catalyst optimization 1, 2, and 3	Optimize catalyst: improve their chemical structure, design to lower reaction temperatures, and improve chain reactions
Energy management	Run energy conservation programs including: raising energy and GHG awareness of personnel, reviewing the energy and GHG management system (including monitoring KPIs vs targets), and introducing an energy management focus in all processes
Maintenance and process control	Perform additional/ improved maintenance that ensures equipment stays in optimal condition, e.g., maintenance and monitoring of steam traps/ steam distribution or monitoring and reduction of fouling Improve process control to reduce suboptimal performance (due, for example, to pressure drops across gas turbine air filters or suboptimal turbine washout frequency)
Investments at process unit level	Implement efficiency-enhancing replacements/ upgrades/ additions that do not alter the process flow

Glossary

Adjusted boe: The number of barrels of crude oil that may be purchased by the total monetary savings accrued from a single measure that utilizes a (mix of) value added fuels.

Boe: Barrel of oil equivalent.

Building envelope (shell): The elements of a building which enclose conditioned spaces and through which thermal energy may be transferred to or from the exterior.

Business-as-usual (BAU): Baseline scenario to which reduction potential refers. Based primarily on external forecasts, in this case, PRIMES.

Capex: Incremental capital expenditure (investment) required for a savings measure compared with business-as-usual.

CFL: Compact fluorescent light or lamp.

CHP: Combined heat and power (plant).

CO_2: Carbon dioxide.

CO_2e: Carbon dioxide equivalent or the unit for emissions that, for a given mixture and amount of greenhouse gas, represents the amount of CO_2 that would have the same global warming potential when measured over a specific timescale (generally, 100 years).

Decision maker: The party that decides on making an investment, generally either a company (e.g., as owner of an industrial facility) or an individual (e.g., as owner of a car or a home).

Degree Days, Heating and Cooling: The difference between a reference temperature (usually 65°F [18.3°C]) and the mean temperature for the day, times the number of days in the period. Degree days are used to compare the severity of cold or heat during the heating or cooling season.

E100: The energy usage in buildings in Flanders is measured by the E-value, and is expressed as a percentage of the energy consumption of the reference building called E100.

EAF: Electric arc furnace – for steel production, in contrast to the integrated route of blast furnace and oxygen steel converter.

Energy Performance Contracting: Contractual arrangement between the beneficiary and the provider (normally an ESCO) of an energy efficiency improvement measure; investments in that measure are paid for in relation to an agreed level of energy efficiency improvement.

Energy efficiency: A ratio between an output of performance, service, goods or energy, and an input of energy.

Energy efficiency improvement: An increase in energy end-use efficiency as a result of technological, behavioral and/or economic changes.

EPBD: Energy Performance of Buildings Directive.

ESCO (Energy Service Company): Organization that delivers energy services and/or other energy efficiency improvement measures in a user's facility or premises, and accepts some degree of financial risk in so doing as payment for the services delivered is based (either wholly or in part) on the achievement of energy efficiency improvements and other agreed performance criteria.

EV: (Battery) Electric Vehicle.

Euro or €: Real 2005 Euros.

Frozen technology: Increase in energy consumption due to growth in production considering the current (2005) technology level fixed over time, thus no efficiency gain of current technologies or from newly emerging technologies.

Full hybrid vehicle: Full hybrid vehicles have a conventional internal combustion engine plus an electric engine that runs on a battery; the battery get charged by the drive cycle of the car (e.g., by braking) only.

GDP: Gross domestic Product is the value of all final goods and services produced in a specific country. It is the broadest measure of economic activity and the principal indicator of economic performance.

Greenhouse gas (GHG): Greenhouse gas in the context of the Kyoto protocol – CO2 (carbon dioxide), CH4 (methane), N2O (nitrous oxide), CFC (chloro fluorocarbons), SF6 (Sulfur Hexafluoride).

HVAC: Heating, Ventilation, and Air Conditioning.

ICE: Internal combustion engine.

kWh: Kilowatt hour(s) is the standard unit of measure for electric energy. One kilowatt-hour is one kilowatt of electricity supplied for one hour.

Net Present Value: The total discounted value of all of the cash inflows and outflows from a project or investment.

OpEx: Incremental operational expenditure required for a savings measure compared with business-as-usual. Includes incremental operational and maintenance cost and incremental savings.

PHEV: Plug-in hybrid vehicles have a conventional internal combustion engine plus an electric engine that runs on a battery; the battery gets charged externally through a connection to the power grid.

Public-private partnership: Mechanism for using the private sector to deliver outcomes for the public sector, usually on the basis of a long-term funding agreement. Public private partnerships can take many different shapes: service contracts, operation and management contracts where the public sector bears financial and operational risks; leasing-type contracts, where the private sector leases an asset and runs it with no obligation to transfer it to the government; Build-Operate-Transfer, where the private sector has to transfer the asset back to the government once the lease runs out; Design-Build-Finance-Operate where the private sector has no obligation to transfer the asset back to the government.

Retrofit: To add or substitute new components to an existing building or industrial installation that were not previously available.

Societal perspective: The perspective of costs and benefits for society – it does not include program costs, taxes or incentives

T5/T8/T12 standards: Types of fluorescent tubes. The number refers to the diameter of the tube (in 1/8ths of an inch). A T8 would have a diameter of 1 inch. The T5 and T8 bulbs are more energy-efficient than the T12.

USD or $: Real 2005 US Dollars.

Well-to-wheel efficiency: Well-to-wheel is the specific Life Cycle Assessment of the efficiency of fuels used for road transportation. It refers to the total environmental impact from the extraction of the fuel to the point it is used by the car. The analysis is often broken down into stages such as “well-to-tank” and “tank-to-wheel”.

Energy conversion factors

BOE AND ADJUSTED BOE

Boe: Barrel of oil equivalent, the energy released by burning one barrel of crude oil. This is a method for comparing the energy contents of oil, gas and other fuel sources. Gas is converted to oil based on its relative energy content at the rate of 6 mcf of gas to one barrel of oil. NGLs are converted based upon volume: one barrel of natural gas liquids equals one barrel of oil.

Adjusted boe: the number of barrels of crude oil that may be purchased with the monetary value of the energy savings made. For example, by saving the energy equivalent of 1 boe of gasoline, we can purchase 1.71 adjusted barrels of crude oil because 1 boe of gasoline is worth 1.71 boe of crude oil. The value-add multiplier is fuel-specific.

Multipliers used to adjust for value adding processes

Fuel / energy	Multiplier cost-to-society
Coal	0.25
Gas	0.61
Fuel oil	0.68
Crude oil	1.00
Electricity	1.67
Gasoline	1.71

PRIMARY TO FINAL DEMAND CONVERSION

Primary energy consumption indicates the total energy use in a given country. When assessing the energy and GHG emissions that can be saved for the benefit of a given economy from a societal perspective, it is necessary to work with primary energy consumption numbers.

Final energy consumption indicates the energy available for final use after transformation and distribution. Feedstocks, i.e., energy products used as raw materials in producing other products (e.g., coking coal used in a blast furnace to produce steel, gas cracked in a petrochemical plant to produce chemicals) are not included in the final or primary energy numbers.

For Buildings, the final energy demand approximated 77 percent of primary demand in 2005. This is because most space and water heating systems consume a mix of primary energy sources, while appliances, electronics, some HVAC systems and lighting use electricity.

For Road Transportation, refining and transportation losses are a lot more limited, and in 2005 final demand was 98 percent of primary demand.

Industry uses crude energy, electricity, and steam in a mix that varies from sector to sector. Final energy demand was about 66% of primary demand in 2005. Fuel used for feedstock purposes is not included in this analysis.

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