THE 2015 ENERGY PRODUCTIVITY AND ECONOMIC PROSPERITY INDEX

How Efficiency Will Drive Growth, Create Jobs and Spread Wellbeing Throughout Society

By Kornelis Blok, Paul Hofheinz and John Kerkhoven

ECOFYS
the Lisbon council think tank for the 21st century
QUINTEL INTELLIGENCE

PHILIPS

The study was financed by a grant from Philips, a diversified technology company focused on improving people's lives through meaningful innovation in the areas of healthcare, consumer lifestyle and lighting. Its website is www.philips.com.

THE 2015 ENERGY PRODUCTIVITY AND ECONOMIC PROSPERITY INDEX

How Efficiency Will Drive Growth, Create Jobs and Spread Wellbeing Throughout Society

Principal Authors:
Kornelis Blok, Paul Hofheinz and John Kerkhoven

Project Team:
Pieter van Breevoort (research lead), Joris Berkhout, Sergey Filippov, Paul Noothout, Wouter Terlouw, Harry Verhaar and Alexander Wirtz

Kornelis Blok is director of science at Ecofys, a leading knowledge and innovation company in the field of renewable energy, energy efficiency and climate change based in Utrecht, Netherlands. Its website is www.ecofys.com.

Paul Hofheinz is president and co-founder of the Lisbon Council, a Brussels-based think tank. Its website is www.lisboncouncil.net.

John Kerkhoven is managing partner of Quintel Intelligence, a Dutch energy modelling and research firm that assists governments, companies and institutions around the world in determining and quantifying their long-term energy strategies. Its website is www.quintel.com.

THE 2015 ENERGY PRODUCTIVITY AND ECONOMIC PROSPERITY INDEX

Contents

How Efficiency Will Drive Growth, Create Jobs and Spread Wellbeing Throughout Society

Tables and charts

Tables

Charts

Country and Economy Overviews

‘The world is deploying new technology much too slowly to keep up with rising energy demand.’

Even in the midst of a stubborn, on-going crisis, the world economy is growing steadily. The earth’s population surpassed the seven billion mark in 2011, up from one billion as recently as 1800 (the first year the human population crossed the symbolically important one billion mark).[1] Of those seven billion, more and more are attaining levels of literacy and education that were once the sole prerogative of the developed world – and entering the global workforce. The economic prosperity brought by this flourishing of truly global trade has raised standards of living globally, enriching lives in the developed world, and brought the first signs of prosperity to many whose ancestors only recently eked out a marginal existence. Huge advances in global health mean that billions more people live longer, better lives – and not just Europeans, whose rapidly ageing population poses challenges with which policymakers have only begun to grapple.[2] And the great leap in prosperity and economic growth that began with the Industrial Revolution – and the harnessing of powerful new energy carriers like steam – is hardly over. The International Energy Agency (IEA) assumes that the global economy will continue growing at 3.6% per year in coming decades, putting added strains on the earth’s already limited natural resources and energy supplies.[3]

Is this a good thing? The answer is most certainly “yes,” though it does put new and pressing responsibilities upon us – as citizens, as nations and as members of the human race. All of this growth and social advancement stemmed from a handful of fundamental leaps in human technology, most notably in the field of energy. “The steam engine marked the decisive turning point of modern history,” writes Prof Jeffrey D. Sachs. “Modern energy fuelled every aspect of the economic take-off. Food production soared as fossil-fuel energy was used to produce chemical fertilizers; industrial production skyrocketed as vast inputs of fossil fuel energy created equally vast powerhouses of steel, transport equipment, chemicals and pharmaceuticals, textile and apparels, and every other modern manufacturing sector.”[4]

The good news is that the efficiency and productivity with which we use energy is also improving steadily. These days – even with the on-going economic growth and development we see on a global scale – energy productivity increased at an average 1.3% per year worldwide between 2001 and 2011. The bad news is that this improvement, welcome as it is, is still not enough to keep up with the fast pace of demographic and economic change, which causes us to continue consuming the earth’s resources at a staggering rate. This, in turn, creates ever-growing problems with global weather patterns and climate, costs households and businesses an inordinate amount of money and distorts the world’s politics by making some regions unnecessarily dependent on the goodwill of others.[5] Technology has long since put vastly more efficient machinery and energy sources in our fingers, but the world is deploying that new technology much too slowly to keep up with rising energy demand and confine resource demand within sustainable limits. An overreliance on fossil fuels – and an inability to use the energy we generate

1 The global population has expanded consistently since the end of the great famine and black death in 1350. The highest growth rates – 2.2% per year – were recorded in the 1960s.
2 European Commission, *The 2012 Ageing Report* (Brussels: European Commission, 2012).
3 International Energy Agency, *World Energy Outlook 2013* (Paris: IEA, 2013).
4 Jeffrey D. Sachs, *The End of Poverty: How We Can Make It Happen in Our Lifetime* (London: Penguin, 2005).
5 Intergovernmental Panel on Climate Change (IPCC), *Impacts, Adaptation, and Vulnerability, Fifth Assessment Report* (Cambridge: Cambridge University Press, 2014).

'Societies cannot change what they cannot measure.'

much more efficiently – has placed a large question mark over the future development of our society. Will we continue the slow but uneven rise to global prosperity on which the Industrial Revolution propelled the human race some two centuries ago? Or will we allow our inability to launch a renewed Industrial Revolution – a revolution based on more aggressively deploying the energy-saving technologies we already possess – to lock us onto a globally unsustainable path, pushing much of the world backwards to a life of ever lower living standards, less prosperity, higher energy bills and over-reliance on the benevolence of our neighbours?

That is why we created **The Energy Productivity and Economic Prosperity Index**, an effort to gauge the efficiency and effectiveness with which energy resources are being used worldwide. Put simply, societies cannot change what they can't measure. And while we know a lot about how much energy the world consumes annually (560 exajoules in 2012), we are not very good at monitoring our progress in the vital area of energy productivity where so much future wellbeing will be determined.[6] Even today – in an era where technology has lowered the marginal cost of vital services like global communication to nearly zero – we still squander more than 98% of all of the energy we produce through inefficient use and wasteful means of transport and production. When you boil an egg in a pot of water, for example, only 2% of the energy consumed in the process actually goes to the boiling of the egg. And the situation is roughly analogous with the rest of the economy, where nearly 98% of all energy we use in the process of production is wasted rather than being converted into useful services and products.

In this policy brief – using models produced by Quintel Intelligence – we will show that Europe could double its energy productivity performance on the basis of existing technologies.[7] This is not a Calvinist vision of a more hirsute future. To the contrary, this "High Energy-Productivity Growth Scenario," as we call it, would not only bring no appreciable reduction in lifestyle and prosperity; it would actually add to lifestyle quality by freeing up more money for spending on health, recreation and education.[8] The effect would be felt at the national level – where countries would have more money to invest on desirable social goods. But it would also create a palpable difference at the household level where, after an initial investment, it would dramatically cut the amount households spend on routine energy use. As part of this analysis, we have included a sample household energy bill, which shows how under the High Energy-Productivity Growth Scenario, the average European consumer would pay around €82.45 per month in energy costs, down from the average €123.27 today. (You will find the sample energy bill on page 8). The model takes actual energy consumption today as its starting point, deploying a bottom-up micro approach to assess future energy use. The advantage is that one can use these models to see where energy is actually being consumed – and where it could be consumed much more productively with a few changes

6 We define energy productivity as the volume of services or products that can be generated per unit of energy. It is not the same as energy efficiency, which measures the inverse, i.e., how much energy is needed to produce a given level of output. See International Energy Agency, *Key World Energy Statistics 2014* (Paris: IEA, 2014).

7 Quintel Intelligence is a Dutch energy modelling and research firm that assists governments, companies and institutions around the world in determining and quantifying their long-term energy strategies. It developed and maintains the Energy Transition Model, upon which the future scenarios in this paper are based. Visit www.quintel.com.

8 Under the High Energy Productivity Growth Scenario, Europe's annual energy demand would decrease to around 30 exajoules per annum in 2030, down from 45 exajoules per annum in 2012, a 30% improvement on the Business-As-Usual Scenario.

'Doubling energy productivity would reduce the global fossil fuel bill by more than €2 trillion and could create more than six million jobs globally by 2020.'

based on existing technology. The result is a very accurate and reliable simulation of future activity in the energy-consumption field.

The policy brief has four parts. Part I, which begins on page 9, will look at energy productivity on a national basis in a global context, ranking countries based on their performance on energy productivity regardless of their economic level of development or the structure of their economy. Who is doing well on energy productivity? Who is improving most quickly? Who needs to do better? Part II, which begins on page 14, will break energy use down into three of its four main components: households and appliances, which account for 23% of overall energy use worldwide; services (including agriculture and non-residential buildings), which accounts for 11%; and industry, which accounts for 29%.[9] It will rank countries based on their performance in each of these areas, looking again at both the best performers and the fastest improvers.[10] The goal is to give policymakers a more nuanced understanding of how their country is doing and where their country most needs to improve to raise its overall performance on energy productivity. Some do well in some areas, but less well in others. And the most improvement is possible in areas where countries do worst. This portion of the index was created to help policymakers see where they have the most work to do, based on a relatively nuanced assessment of their country's actual energy performance and needs. Part III, which begins on page 23, goes into even greater detail for six European countries (France, Germany, Spain, the Netherlands, Poland and the United Kingdom) and for the European Union as whole.[11] Using the Energy Transition Model developed by Quintel Intelligence, it looks at the actual potential for each of these countries to double their energy productivity by 2030 – and discusses the technologies they will need to deploy to do so. In Part IV, which begins on page 32, we offer conclusions and policy recommendations.

Overall, this policy brief has a singular mission: to arm policymakers with the analytical tools they will need to raise energy productivity in the countries, regions and cities they know best. To that end, it is intended both to scold and to inspire. We can, all of us, raise our game in energy productivity – both at the national, regional, local and even the personal level. The 2015 Energy Productivity and Economic Prosperity Index helps us see where we need to improve, and, if it has successfully accomplished the task we set for it, it also shows us that significantly better performance is within our reach. With a bit of effort from all of us and a sufficiently ambitious vision from our leaders, we can in fact build a better world. The 2015 Energy Productivity and Economic Prosperity Index is here to show us how.

9 The fourth major energy-using sector is transport, which accounts for around 27% of overall energy use. We found significant data anomalies involved in the transport data, and chose not to include it in this survey. It is our hope that these data anomalies can be resolved and reliable transport rankings included in future editions of this study.

10 The ranking in this section is confined to the EU-27, which includes all 27 European Union member states minus Croatia, which joined the EU in 2013.

11 Interested readers can also visit the Quintel Intelligence website, where the Energy Transition Model is available on a country-by-country basis in an interactive format. Readers can programme in their own assumptions or wishes regarding future energy-use in key areas and see the likely outcome in 2030. Visit www.energytransitionmodel.com.

12 International Energy Agency, *Energy Balances of Non-OECD Countries* (Paris: IEA, 2013).

13 Two countries – India and the Russian Federation – have seen energy productivity-based boosts to their GDP of 23% and 29%, respectively, over the last 10 years. See Chart 1 on page 14 for more.

14 International Energy Agency, World Energy Outlook 2012 (Paris: IEA, 2012).

15 We will discuss the jobs implications of a doubling of energy efficiency in Part IV, presenting evidence that shows how greater efficiency leads to more jobs, particularly in the "high value-added," or "good-jobs," end of the labour force.

‘Huge advances in global health mean that billions more people live longer, better lives.’

Key findings

1. All regions of the world could improve their energy-productivity performance dramatically based on more aggressive adoption of existing technology. For the developing world, there is a chance to “leapfrog” the developed world and move speedily towards cost-saving energy- productivity levels. For the developed world, we believe Europe alone could see an economic expansion of 35% by 2030 *and* cut its energy use to 30.1 exajoules per year, a 35% improvement on current levels even while the economy grows at a healthier pace. The forecast is based on current energy use in Europe, rapid deployment of existing technology and economic projections from the European Commission.

2. Most of the improvements will need to come from a strong improvement in energy performance in residential and non-residential buildings, which could bring in annual energy savings of around 4%, respectively, between now and 2030, compared to a “Business-As-Usual Scenario,” which we have developed as a baseline for comparison. Industry, by contrast, would need only save roughly 1% per year to help society achieve the overall efficiency doubling. Transport would need to improve at roughly 2% per annum. Improvements on this size and scale are within the realm of possibility based on broader deployment of technology that exists today.

3. Given the need for building refurbishment to take the lead in delivering broad societal gains, the key technologies will be insulation, energy-efficient appliances and lighting (where an improvement of 500% in energy productivity in average households is already possible) and state-of-the-art heat pumps, which would consume more electricity to operate but do more to improve overall energy efficiency in most buildings.

4. Regulators must be prepared to deploy an arsenal of tools, including mandating high energy-efficiency standards in automobiles, light bulbs, household appliances, refrigerators – and especially buildings. Improved labelling also helps by providing transparency on the energy choices consumers face when they make purchases. For example: under the revised (2010) European Union labelling scheme, many consumers do not know that label A indicates for many technologies a relatively poor performance these days and that label A+++ appliances uses less than half the energy of a label A device.

5. Mostly, policymakers should be prepared to set ambitious targets, use their power of persuasion and promote the benefits of transition on a consistent basis.

6. Progress – to be globally significantly – will be most important in the world’s six largest economies: the European Union, the United States, China, India, the Russian Federation and Japan. Collectively, these six economies account for 60% of global GDP and 65% of global energy demand.[12] However, greater energy efficiency in these economies is a win-win-win scenario. Statistics tell us that these economies have been able to produce on average 18% more GDP in the last 10 years with a given amount of energy thanks to the energy savings they have already made.[13]

7. The IEA estimates that doubling energy productivity gains by 2030 would create at least 1.1% of additional GDP in the EU.[14] Ecofys calculates that the global fossil fuel bill could be reduced by more than €2 trillion (compared to the Business-As-Usual Scenario). Moreover, this would create more than six million jobs globally by 2020, net of any job losses in low-energy-intensity sectors.[15] Improving energy productivity is also a key measure to realise the greenhouse gas emissions reductions needed to keep the global temperature increase within a maximum of two degrees centigrade, the globally agreed target.

‘The economic prosperity brought by this flourishing of global trade has raised the standards of living globally.’

Household bills: The High Energy Productivity Growth Scenario

What would happen if we could double the energy efficiency in the houses where we live? The answer is lower bills. In this simulation, we look at the typical energy cost to a European household in 2030 in the Business-As-Usual Scenario, which was developed based on today’s actual energy consumption combined with existing demographic trends and energy policy commitments already made.[1] Then, we present the same household under the High Energy Productivity Growth Scenario, in which Europe doubles its energy efficiency growth based on more aggressive deployment of existing technologies. The result is one-third lower energy costs per household from today’s prices, and a whopping 37% savings based on the projected energy costs in 2030 according to current trend. What’s more, this is not a one-off savings, but an annual savings that could range between €300 and €600 that would accrue to each of Europe’s more than 200 million households.

In this analysis, we assumed that High Energy Productivity Growth will have no impact on energy prices. In reality, energy prices will be substantially lower in case of reduced demand. This will have a further decreasing impact on household energy bills. Getting there is the tricky part: Our scenario is based on existing technology, including heating (heat pumps) and insulation, more-energy efficient equipment and better lighting. Households would need to invest in these state-of-the-art solutions, but many investments in energy efficient technologies earn themselves back over their lifetime with the reduced energy bill.

ENERGY BILL 2030

	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)
Prices			
Natural gas price (m3)	€0.65	€0.84	€0.84
Electricity price (kWh)	€0.18	€0.21	€0.21
Total costs per month			
Natural gas	€59.63	€62.87	€31.28
Electricity	€63.64	€68.00	€51.17
Total	€123.27	€130.87	€82.45

Under these scenarios, natural gas and electricity prices for households rise proportional to the natural gas price in the PRIMES scenario. The sensitivity of end-user prices to spot-prices is assumed to be 0.5. This means that a 50% increase in spot prices leads to a 25% increase in end-user prices.

‘An over-reliance on fossil fuels – and an inability to use the energy we generate much more efficiently – has placed a large question mark over the future development of society.’

Part I: Energy Productivity: A Global Ranking

Who enjoys the world’s highest energy productivity? Oddly, the answer is **Hong Kong**, the Chinese island state.[15] Since economic and political integration with China in 1997, the island now boasts a nearly 100% service-based economy, having outsourced large swathes of its manufacturing to Guangdong province, just across Pearl River delta. Another top performer is **Cuba** (No. 2).[16] After the collapse of the Soviet Union, the island state had to restructure its economy drastically to learn to live without the cheap energy the USSR had until then routinely provided (in 2005, it became the first nation in the world to ban the sale and import of incandescent light bulbs).[17] The result is something of a revolution. While Cuba remains well behind the rest of the world in industry, exports and overall level of development, it has become a world leader in energy productivity, weighing in at a show stopping €365 billion of gross domestic product per exajoule of energy consumed, the best energy performance in the world.[18]

Economies like Cuba’s are an anomaly. Its level of economic development is not high enough to warrant serious comparison with, say, the **United States**, its northern neighbour, which ranks No. 87 (at €143 billion of GDP per exajoule) on the global list of countries ranked by their energy productivity performance (see Appendix I on page 49 for a full global ranking, based on prime energy consumption and excluding non-energy use), just ahead of the global average (just below €143 billion of GDP per exajoule).[19] The countries whose performances are worth noting in this context are **Singapore** (No. 4 globally, at €329 billion of GDP per exajoule) and **Switzerland** (No. 5 globally, with €310 billion of GDP per exajoule). They show that even advanced economies can perform at a high level of energy efficiency.

The purpose of this paper is not to focus on issues of economic development and energy efficiency – though it is worth noting in passing that many developing countries have an inbuilt advantage; if they are clever, they can leapfrog the long period of energy intensive economic development that characterized the Industrial Revolution and use new technologies to move immediately to cleaner, more efficient forms of energy consumption. That appears to be what is happening in **Azerbaijan** (whose energy-productivity performance is improving annually at 12.8%, the fastest rate of energy productivity improvement in the world), **Uzbekistan** (No. 2, with an 8.1% per annum improvement), **Tajikistan** (tied at No. 3, with a 6.6% improvement) and **Lithuania** (also No. 3) which lead the league table on average annual improvement in energy productivity

16 The full Global Energy Productivity Index and Improvement in Global Energy Productivity Index appear as Appendices I and II, beginning on page 49.

17 Paul Waide, *Phase Out of Incandescent Lamps: Implications for International Supply and Demand for Regulatory Compliant Lamps* (Paris: IEA, 2010).

18 Even more amazing as Cuba’s overall annual GDP is only around €54.1 billion (2011). See also Peter Rosset, “The Greening of Cuba,” *ACLA Report on the Americas: Vol. 28:3* (New York: North American Congress on Latin America, 1994).

19 If the European Union were a country, it would rank No. 42, well ahead of the US (No. 82).

‘Will we allow our inability to launch a renewed Industrial Revolution to lock us onto a globally unsustainable path?’

over the last decade (the full global ranking on average annual energy productivity improvement, see Appendix II on page 53). The results in **China**, however – one of only two developing country large enough to make a real impact globally – are disappointing. Ranked at No. 111, China produces only €98 billion of GDP per exajoule of energy consumed. And China is No. 58 on the Improvement in Energy Productivity Index, averaging only a 1.8% annual improvement over the last decade, just ahead of the OECD average (1.7%).

Our purpose, however, is to look more closely at energy consumption in the larger counties, focusing on how the big economies that matter most for the global economy are

Table 1: The Energy Productivity Index (Top 50)

in billions of euros of GDP per exojoule of energy consumed

Rank	Country	Productivity	Rank	Country	Productivity
1	Hong Kong SAR, China	456	27	France	186
2	Colombia	330	28	Saudi Arabia	181
3	Singapore	329	29	Pakistan	174
4	Switzerland	310	30	Malaysia	172
5	Peru	287		*OECD members*	171
6	Philippines	256	31	Poland	165
7	Italy	246	32	Thailand	163
8	Portugal	242	33	Belgium	162
9	Spain	236	34	India	159
10	Turkey	234	35	Sweden	158
11	United Kingdom	231	36	Australia	150
12	Bangladesh	228	37	United Arab Emirates	148
13	Algeria	225	38	United States	143
14	Egypt, Arab Rep.	224		*World*	143
15	Norway	224	39	Nigeria	138
16	Greece	220	40	Venezuela, RB	137
17	Germany	220	41	Vietnam	135
18	Austria	217	42	Korea, Rep.	134
19	Netherlands	215	43	Czech Republic	131
20	Brazil	210	44	Canada	118
21	Iraq	207	45	Iran, Islamic Rep.	117
	European Union	206	46	China	98
22	Mexico	201	47	Russian Federation	92
23	Chile	201	48	South Africa	85
24	Japan	196	49	Kazakhstan	85
25	Indonesia	195	50	Ukraine	60
26	Romania	192			

The 50 countries chosen are the world’s 50 largest based on purchasing power parity adjusted GDP.
The euros are taken at their 2012 rate, purchasing power parity adjusted.

‘Nearly 98% of all energy we use in the process of production is wasted rather than being converted into useful services and products.’

faring in this area. You will find the results in Table 1: **The Energy Productivity Index (Top 50)** on page 10. In this table, we have taken the world’s 50 largest economies, established by purchasing power parity-adjusted GDP, and ranked them according to the amount of GDP they produce relative to the amount of energy they consume.

The results confirm some important trends: namely, countries that have evolved more emphatically away from energy and towards a service-driven economy also have a lighter energy footprint. **Hong Kong** (at No. 1, with an economy which is nearly 100% services), **Singapore** (No. 3), **Switzerland** (No. 4), and the **United Kingdom** (No. 11, with €231 billion of GDP per exajoule) are good examples. But the ranking also shows remarkably strong performance from industrial powerhouse **Germany** (at No. 17, with €220 billion of GDP per exajoule of energy), which shows that countries can set a high standard for industrial development and energy productivity at the same time. Germany also leads on energy-productivity improvement, weighing in at No. 14 with an average 2.27% annual improvement in the last decade. Indeed, far from costing industry their advantage, there is mounting evidence that high energy and environmental standards can themselves form the basis for competitive advantage by lowering energy costs and helping companies to compete.

Table 2: **The Improvement in Energy Productivity Index (Top 50)** on page 12 looks not at the actual amount of GDP produced per unit of energy consumed. Instead, it looks at the speed with which countries are improving (this ranking is again limited to the world’s 50 largest economies, chosen based on ppp-adjusted GDP). Here, perhaps surprisingly, some of the world’s worst overall performers (**Nigeria** at No. 39 on overall performance) are among the best performers when measured by average annual improvement (Nigeria is No. 1 on improvement with 6% annual energy productivity growth). There is a simple explanation: improvement is easy to measure from a relatively low base. But far more concerning are the countries in this ranking that are actually going backwards, defying a global trend and delivering increasingly poor performance, year-on-year, on energy productivity: **Iraq** (No. 45, with an average 0.3% annual decline), **Egypt** (No. 46, with a 0.4% decline), **Mexico** (No. 47 with a 0.4% decline), **Kazakhstan** (No. 48, with a 0.8% decline), **Algeria** (No. 49, with a 0.9% decline) and **United Arab Emirates** (No. 50, with a 1.6% decline). These countries would benefit greatly from paying much closer attention to their development strategy, and looking to reap more benefit from modern technology to produce and consume energy more productively.

When it comes to energy consumption, size most certainly does matter. The world’s six largest economies, for one, produce 60% of global GDP and consume 65% of global energy consumed.[20] The result is – while smaller industrial countries like Hong Kong and Singapore can set the standard for efficient energy use in highly developed economies – we must turn our attention to the world’s larger economies if we want to see major change on a global scale. Here, the record is surprising optimistic. Statistics show that, far from destroying jobs and harming growth, high levels of energy efficiency have

20 International Energy Agency, *Energy Balances of Non-OECD Countries*, op. cit.

‘Europe could double its energy productivity performance on the basis of existing technologies.’

Table 2: Improvement in Energy Productivity Index (Top 50)

Underlying figures in billions of euros of GDP per exajoule of energy consumed (2001-2011)

Rank	Country	Growth per year
1	Nigeria	6,45%
2	Ukraine	4,87%
3	Romania	4,31%
4	Singapore	4,29%
5	Philippines	4,24%
6	Hong Kong SAR, China	4,01%
7	Russian Federation	3,47%
8	United Kingdom	3,28%
9	Poland	3,06%
10	Czech Republic	3,00%
11	India	2,63%
12	Sweden	2,59%
13	Indonesia	2,54%
14	Germany	2,27%
15	Switzerland	2,26%
16	Colombia	2,08%
17	Canada	2,04%
	European Union	1,89%
18	United States	1,82%
19	Japan	1,76%
20	China	1,75%
	OECD members	1,66%
21	Belgium	1,53%
22	Australia	1,52%
23	Pakistan	1,51%
24	Netherlands	1,47%
25	Malaysia	1,46%
26	Greece	1,43%
27	Spain	1,39%
28	Korea, Rep.	1,38%
	World	1,32%
29	France	1,31%
30	South Africa	1,14%
31	Bangladesh	1,03%
32	Venezuela, RB	1,00%
33	Portugal	0,96%
34	Saudi Arabia	0,94%
35	Norway	0,80%
36	Iran, Islamic Rep.	0,74%
37	Austria	0,69%
38	Turkey	0,60%
39	Italy	0,50%
40	Peru	0,49%
41	Thailand	0,27%
42	Chile	0,15%
43	Brazil	0,14%
44	Vietnam	-0,05%
45	Iraq	-0,25%
46	Egypt, Arab Rep.	-0,38%
47	Mexico	-0,39%
48	Kazakhstan	-0,82%
49	Algeria	-0,90%
50	United Arab Emirates	-1,56%

‘The biggest improvement is possible where countries do worst.’

contributed – and contributed heavily – to economic growth in many of the world’s most prosperous countries. Table 3: **Contribution of Energy Productivity to GDP Growth** looks at the role of rising energy productivity in the economic performance in the world’s six largest economies. Statistics tell us that these countries and regions were able to produce on average 18% of their GDP in the last 10 years thanks to energy productivity improvements.[21] In the **European Union**, for one, improving energy productivity helped facilitate 17% of GDP in 2011. And, in **India** and the **Russian Federation**, it contributed fully 23% and 29% of additional growth from the same amount of energy in that time frame. Interestingly, the **World** itself (with some 214 countries and territories in the calculation) saw a relatively low 12% boost through improved energy productivity in that time, i.e., the rate of energy productivity improvement in smaller countries is slower than the improvement we see in the highly developed countries (the big six and the **OECD**, where the ten-year improvement is 15%).[22] This shows that there is considerable room for improvement in the developing world, though the vast burden of bettering the global energy consumption performance most certainly lies with the world’s largest economies.

Table 3: Additional GDP facilitated through increased energy productivity (The big six, OECD and the world)

In 2012 euros

Rank	Country or Area	Percent of GDP gained from higher energy productivity growth	Annual Energy Consumption (in exajoules)		Energy Productivity (in billions of euros per exajoule of energy consumed)		Change	GDP (in billions of euros)
			2011	2001	2011	2001		2011
1	Russian Federation	29%	28	25	92	65	739	2555
2	India	23%	30	18	159	123	1079	4722
3	EU 27	17%	65	68	206	171	2287	13381
4	United States	16%	86	87	143	119	2028	12301
5	Japan	16%	18	20	196	164	555	3473
6	China	16%	109	48	98	82	1700	10687
	OECD	15%	207	205	171	145	5379	35393
	World	12%	515	399	143	125	9008	73416

Sources: Worldbank, International Energy Agency, Ecofys analysis

21 The calculation is made by looking at the 2001 and 2011 GDP levels and the 2001 and 2011 energy consumption levels. A figure is then derived for the overall energy productivity level of the country or region in that ten-year period. And a further calculation is made based on actual energy use to find what the level of 2011 GDP would have been had the economy remained at the 2001 level of energy productivity. The result is a calculation of how much smaller the economy would be if it had retained the old level of energy productivity, and, by extension, of the GDP growth during that time which can be at least partially attributed to overall energy efficiency improvements throughout the economy.

22 The OECD is made up of 34 the world’s best performing, wealthiest economies.

‘All regions of the world could improve their energy-productivity performance dramatically based on more aggressive adoption of existing technology.’

Part II. The Components of Energy Productivity: How Countries Rank

Economies consume energy primarily in four distinct areas: transportation, households and appliances, services and industry.[23] In this section, we will rank the European Union’s 28 economies based on their performance in six sub-indicators for the last three areas – looking both at their overall performance per sector as well as the speed with which they are improving in each of those sectors.[24] The goal is to help countries understand where they excel – and where they could clearly stand to improve. And places that do badly should take heart: countries with the worst performance also hold the most opportunity for dramatic improvement.[25]

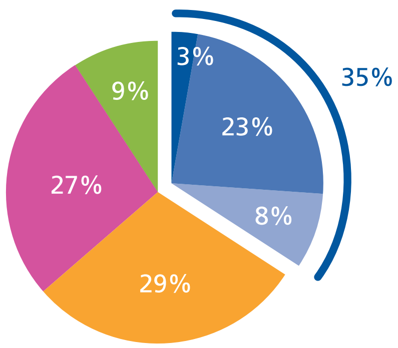
II.1 Households and Appliances (Buildings and Heat Productivity) Sub-Indicator

Appliances and the heating of buildings account for around 31% of the total amount of energy consumed each year in the world (for a full breakdown, see Chart 1 **Energy Consumption by Sector, EU-27 and the World**). Interestingly, while EU industry’s share in total consumption is relatively limited – the 24% of overall energy consumption for the industrial sector is less than the 29% share of energy that is going into industry worldwide – the EU consumes considerably more in buildings, where fully 36% of our energy use is consumed (versus a global figure of 31%). These figures provide interesting information. They show that, if Europe is to continue leading

Chart 1: Final energy consumption by sector

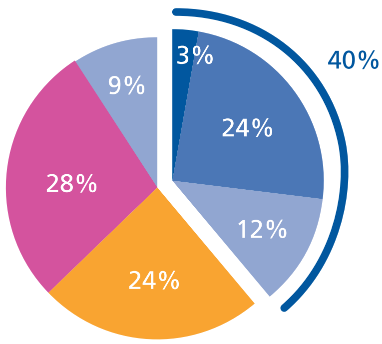
	WORLD	EUROPEAN UNION
Industry	107	11
Transport	102	13
Non-energy use	34	4
Other, of which:	130	19
Fishing and agriculture	13	2
Buildings, of which:	117	18
Residential buildings	87	12
Commercial buildings and public services	30	6
All sectors	**373**	**48**

World



World Energy Consumption

EU 27



EU-27 Energy Consumption

Source: International Energy Agency

23 For the remainder of this study, we will focus on Europe and the European Union, which, if it were a nation, would be the largest economy in the world and the third largest energy consumer (behind the United States and China).

24 Transportation was also researched, but unfortunately the data was not consistent across countries. The ranking contained uncertainties too large to draw firm conclusions, so we have left transportation sector out of the survey. We hope to resolve these data inconsistencies in future editions.

25 In developing these indicators we combined different data sets. Each dataset has its own uncertainties and slight methodological variations across countries. This means that the indicators have uncertainties as well. We invite the reader to keep this in mind and draw conclusions based on the larger rather than the smaller difference between countries.

‘For the developing world, there is a chance to “leapfrog” the developed world and move speedily towards cost-saving energy-productivity levels.’

the world on energy efficiency and energy-efficiency improvements, it must address the fundamental gap in the energy efficiency of households and buildings.[26] This is where Europe’s major work lies.

In order to track relative performance more closely, we set out to rank relative performance among EU countries in this area. Table 4 **Energy Productivity of Households Sub-Indicator** on page 16 ranks 24 EU countries by the efficiency of their building heating systems, adjusted to account for variations in climate.[27] When we look at building productivity in Europe, scaled to average climate, **Portugal** (No. 1) comes first among the EU-28, weighing in with a 274 square meters heated with every equivalent 1000 cubic meters of natural gas, twice the level of the closest other country (**Bulgaria** at No 2, with 117 square meters) and almost four times the EU average (69 square meters), though structural anomalies related to their economies seem to be the main cause of this relatively high performance.[28] Among the larger economies of Europe, the **Netherlands** (No 5, with 103 square meters) and **Sweden** (No. 6, at 97 square meters) do well. Among the European countries that do poorly are **Ireland** (No. 22, at 65 square meters) and **France** (No. 23, at 52 square meters per 1000 m^3 of natural gas equivalent).

Some countries are catching up rapidly. Table 5 **Improvement in Household Energy Productivity Sub-Indicator** on page 16 shows a ranking of EU countries by the speed with which their building productivity is improving. Interestingly, EU newcomers **Cyprus** (No. 1, with an average annual growth rate of 8.0% in the last decade) and **Slovakia** (No. 2, with average annual growth of 4.4% in the last decade) are improving fastest, rising well ahead of the average EU-country improvement of 2.3% per year. Big countries **United Kingdom** (No. 3 at 4.1%), **Ireland** (No. 4, at 3.5%) and **Netherlands** (No. 10, at 2.6%) also do well, with the Netherlands a notable outlier because it is already a top performer overall in the building productivity and heating category (where it ranks No. 5). Among the countries that need to pay much more attention to building efficiency are **Finland** (No. 22) and **Spain** (No. 23), where no progress was made in the recent decade.

26 It also shows that industry, by and large, is quite efficient in Europe, though continued energy leadership will require that slow but steady gains in energy efficiency in this sector continue to be made.
27 The sample was limited to the EU-27, i.e., without Croatia, which only joined the European Union in 2013. Also, three countries – Belgium, Luxembourg and Malta – do not possess data sets complete enough to be included in the ranking.
28 Portugal is relatively warm with a limited demand for heat. Therefore, its high score is most likely not related to building performance, which is what we set out to measure in this ranking. Put simply, the amount of building space recorded may differ from the amount of building space that is – or is not – actually heated, giving this relatively warm-climate country a statistical advantage. The same could be the case for Bulgaria (although it is on average colder than Portugal). In many Bulgarian households, the heated area is thought to be much smaller than the actual size of dwellings.

‘Policymakers should be prepared to set ambitious targets, use their power of persuasion and promote the benefits of transition on a consistent basis.’

Table 4: Energy Productivity of Households Sub-Indicator

in square meters heated per year per 1000 cubic meters of natural gas consumed, scaled to EU average climate

Rank	Country	Productivity
1	Portugal	274
2	Bulgaria	117
3	Cyprus	108
4	Slovakia	104
5	Netherlands	103
6	Sweden	97
7	Spain	94
8	Lithuania	93
9	United Kingdom	88
10	Germany	86
11	Estonia*	84
	European Union 27	77
12	Denmark	75
13	Czech Rep.	75
14	Poland	72
15	Slovenia	72
16	Finland	71
17	Latvia	71
18	Austria	71
19	Italy	69
20	Romania	68
21	Hungary*	68
22	Ireland	65
23	France	52
24	Greece	46
	Belgium	n.a.
	Luxembourg	n.a.
	Malta	n.a.

* value for 2010
Source: Enerdata/Ecofys analysis

Table 5: Improvement in Household Energy Productivity Sub-Indicator

Growth per year in building productivity heating scaled to EU average climate in square metres heated per year per 1000 cubic meters of natural gas (2001-2011)

Rank	Country	Growth
1	Cyprus	7,97%
2	Slovakia	4,44%
3	United Kingdom	4,09%
4	Ireland	3,50%
5	Slovenia	3,40%
6	Latvia	3,27%
7	France	2,90%
8	Germany	2,81%
9	Austria	2,69%
10	Netherlands	2,63%
11	Czech Republic	2,37%
12	Romania	2,34%
	European Union 27	2,29%
13	Sweden	1,64%
14	Poland	1,55%
15	Estonia*	1,01%
16	Denmark	0,64%
17	Bulgaria	0,41%
18	Italy	0,34%
19	Hungary*	0,29%
20	Greece	0,15%
21	Lithuania	0,08%
22	Finland	-0,34%
23	Spain	-0,78%
	Belgium	n.a.
	Luxembourg	n.a.
	Malta	n.a.
	Portugal	n.a.

* growth over the 2001-2010 period
Source: Enerdata/Ecofys analysis

Warmer households: a key breakthrough at hand

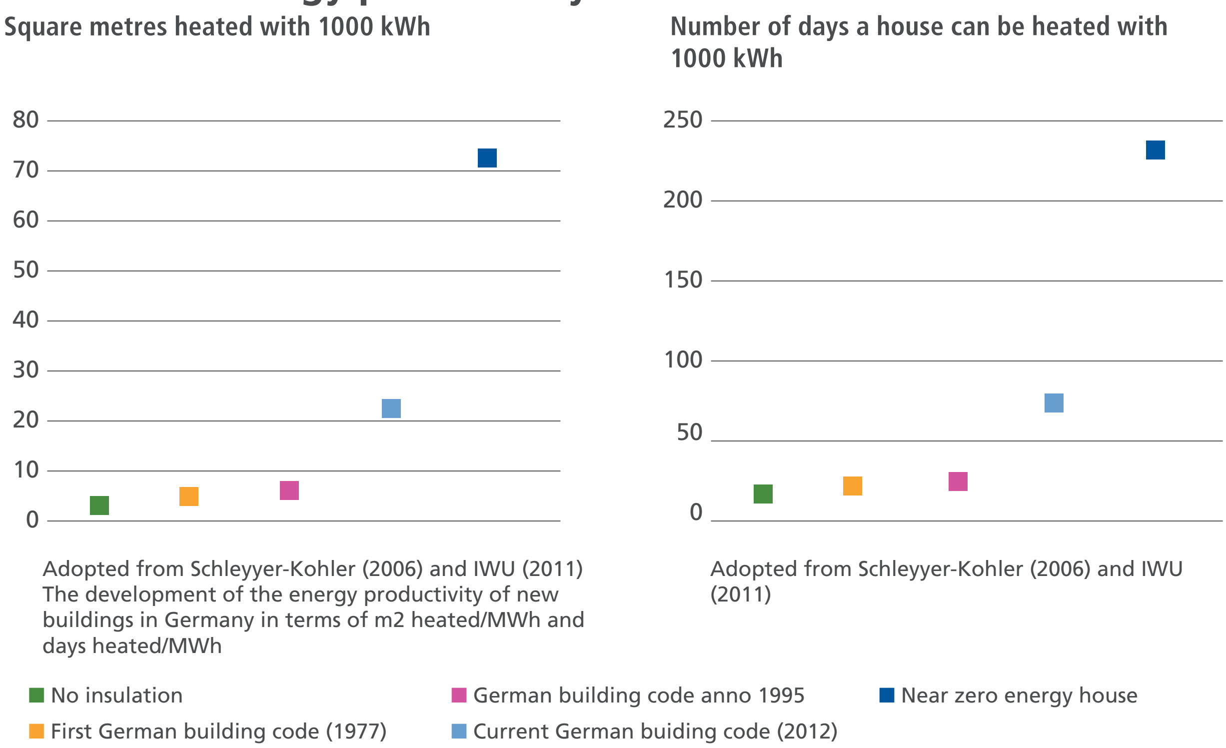
Energy use in buildings has improved dramatically – and could improve even more based on existing technology. A German house, for example, can be heated today for nearly a week with the same amount of energy it would have taken to heat the house for one day in the 1970s.

The main driver for these improvements was the introduction of ambitious building codes in 1977. Building codes describe the minimum level of energy performance of new buildings. Since the 1970s, many countries have implemented building codes, although the minimum requirements vary from country to country.

But the real breakthrough will come when so called "near-zero energy" houses become the rule, rather than the exception. In these types of building, the energy needed for space heating is typically reduced more than 90% compared to the non-insulated buildings. Although near zero-energy buildings (or "passivhaus," as they are called in German) are not part of any binding standard or code yet, they are already being built. Germany is the global leader in this type of buildings with its voluntary "passivhaus" standard already certifying buildings that achieve near-zero energy performance.

A clear upward trend is visible in energy productivity of buildings: more space can be heated with the same amount of energy. Compared to current standards, energy productivity can be further improved by a factor of three-and-a-half, as the tables below show. Alongside of new buildings, there is also much to gain in the existing building stock to which the standards do not apply. In the 2030 High-Energy Productivity Growth Scenario we present in this paper, nearly three average European households can be heated with the same amount of fuel (1000 cubic meters of natural gas) that it took to heat one house in 2012.

Household energy productivity



Adopted from Schleyyer-Kohler (2006) and IWU (2011) The development of the energy productivity of new buildings in Germany in terms of m2 heated/MWh and days heated/MWh

Adopted from Schleyyer-Kohler (2006) and IWU (2011)

Lighting: a revolution in the making

The history of lighting is slow moving, even if the advances to civilisation are easy to spot and see. Throughout history, one technology has replaced another, bringing major lifestyle improvements with it, and often resulting in lower costs (and less risk) for consumers. Today around 900 people can read a book with the same amount of energy it took to allow one person to read a book in the 19th century. The secret of this success is technology, which has evolved substantially since Mesopotamians first began developing oil lamps some 4000 years ago.

Early Mesopotamian lamps were fuelled with oil made from olives and seeds, and oil lamps remained an important light source far into the 18th century. Candles also have a long history; Egyptians and Romans first dabbled in what was then a new technology as far back as 400 BC. But candles were very expensive. For many years, they were used almost exclusively in churches – until the 19th century when the manufacturing process improved and candles became affordable for household use.

At the end of the 19th century a new technology arrived: the gas lamp, which quickly became the major lighting source. They cost around 75% less then candles to operate, and were safer and easier to handle. As a result, they gained market share quickly, but the dominance didn't last long. By the late 19th century, the first incandescent lamps had appeared. They quickly displaced the gas lamp, being the better choice on economy, energy productivity (or luminosity), convenience and safety.

For about a century, no new alternatives were developed – until the 1970's oil crisis inspired the search for more efficient lighting. This resulted in the market introduction of Compact Flourescent Lighting (CFL) in 1980, though the original price tag was too high to ensure widespread deployment.

In the 1960s, another even more promising light source had been discovered, the Light-Emitting Diode (LED). At that time only red lights could be produced and, although other colours were developed during the following decades, the LED remained unsuitable for consumer lighting until 1993 when the first bright blue LED was developed.

In the early 2000s, LED lighting entered the consumer market. As the new lights were expensive, they did not gain market share fast. This changed when several developed countries and regions (including the European Union) proposed a phase out of incandescent lamps in 2009 in an effort to encourage and enforce the transition to this vastly more energy efficient form of lighting. Since then, the cost of LED lights has decreased 85%, making them an affordable choice in houses, offices and public spaces. Current LED bulbs are up to seven times more efficient than incandescent bulbs while lasting about 25 times longer. In 2014, Isamu Akasaki, Hiroshi Amano and Shuji Nakamura received the Nobel Prize for the invention of energy-efficient blue LEDs.

The result is a dramatic acceleration in the amount of energy that can be saved through the use of better lighting. History has shown slow but steady progress, but recent trends amount to a veritable revolution in what is possible – and affordable. In the High-Energy Productivity Growth Scenario we develop in this policy brief, nearly 12 European households could be lit with a 1000 kWh of electricity – which is roughly what it takes to light two households today.

Sources: Tsoa and Waide (2010), Hammer (2008), US EPA (2011), Craven (2012), Brown (2013).

‘The key technologies will be insulation, energy-efficient appliances and lighting and state-of-the-possible heat pumps.’

II.2 Services

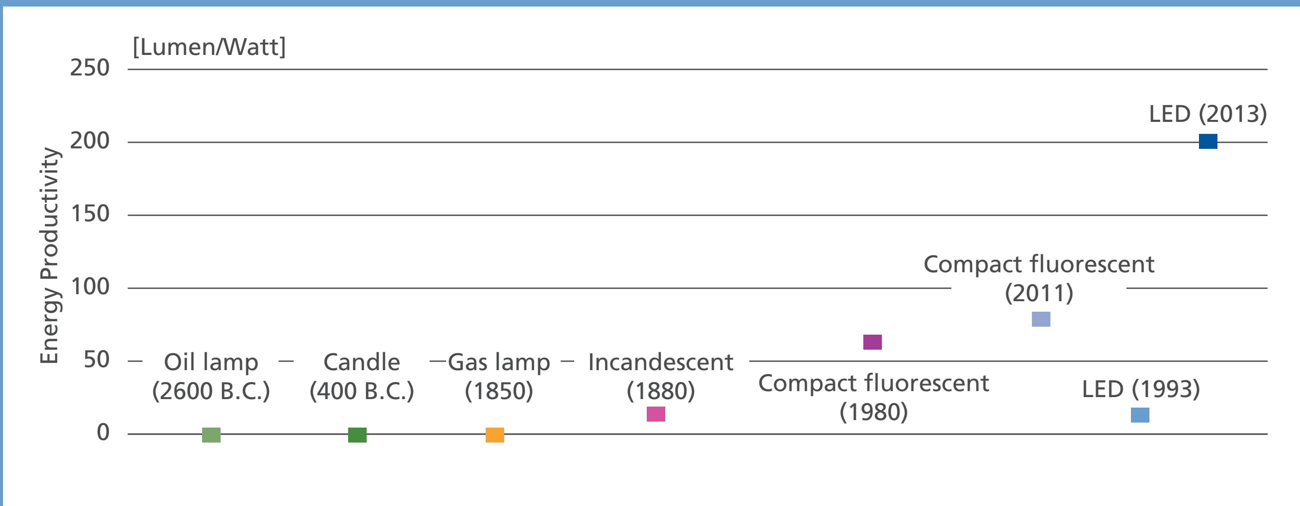
The service sector is in many ways the broadest part of the economy, though its energy footprint is considerably less than manufacturing or transport.[29] This provides an innate advantage to some countries. Countries with a greater percentage of their economy in services (such as **Singapore** or **Switzerland**) often use less energy than countries whose economies are based on a strong manufacturing presence (such as **Germany** or **Ireland**).

But services are not without an energy footprint of their own, and this is what we set out to measure in Table 6 **Service-Sector Energy Productivity Sub-Indicator**, which ranks countries based on the energy efficiency of their service sectors, on page 20.

The **United Kingdom** (at €43 of added value per cubic meter of natural gas equivalent consumed) and **Ireland** (at €42) come No. 1 and No. 2 in this sector, with high-energy productivity performances on top of their already deep presence in services. **Denmark** (No 3, at €37), **France** (No. 4, at €35), **Austria** (No. 5, at €34) and **Luxembourg** (No. 6, at €34) also impress, weighing in above the **EU average** (€31). **Germany** (No. 7, at €31) finishes right at the EU average, a sign that its service sector – while relatively strong – is not an outlier as Germany is in so many other areas, perhaps due to the fact that the German services market remains relatively closed to external competition.

Equally interesting are the countries that are catching up. Table 7 **Service-Sector Energy Productivity Growth Sub-Indicator** on page 21 ranks them. **Romania** (No. 1, at 4.9% average annual improvement), **Slovenia** (No. 2, at 3.1%) and **Slovakia** (No.2 at 3.1%) top the ranking, each of them fast-growing European “catch-up” countries. **United Kingdom** and **Luxembourg** (tied at No. 4 at 3.1%) are next, each delivering similar solid average annual performance improvements

Lighting energy productivity



29 The service sector accounts roughly 8% of all energy consumed in the global economy, though the figure (12%) is somewhat higher for Europe. This reflects the relative advancement of the EU economy, which, like other well-developed economies, has a larger footprint in the service sector. See Chart 1 on page 14 for more.

‘Developing countries have an inbuilt advantage; if they are clever, they can leapfrog the long period of dirty economic development that characterised the Industrial Revolution.’

even though they are already well-developed service-led economies. Sadly, nine European countries showed actual declines in service-sector energy productivity in the ten-year period surveyed, including **France, Belgium** and **Finland** (Respectively No. 21, No. 22 and No. 4, at an average annual decline of just below 1%), **Poland** (No. 25 at -1.1.%) and **Spain** (No. 26, -1.5%) and **Italy** (No. 28 at -2.6%). As with any indicator, weakening performance can come from changes in the nominator or the denominator. In other words, these countries could be consuming more energy per value-added unit in the services sector. Or they could simply have service sectors that are themselves becoming less successful and producing less economic output (i.e., sales and billings) for the same amount of inputs. An analysis of declining service-sector performance in some EU countries is beyond the scope of this paper.

II.3 Industry

Industry in Europe is already moderately energy efficient – perhaps due to the continent’s relative energy dependence as well as the high cost of energy in many manufacturing-based countries. Table 8 **Energy Productivity in Industry Sub-Indicator** ranks EU countries according to the energy productivity of their industry, on page 22. Among the countries with the highest energy productivity averages, one finds several of Europe’s leading economies: **Ireland** (No. 1, at more than €11 per cubic meter of natural gas equivalent consumed), **Denmark** (No. 2, at just below €11), **United Kingdom** (No. 3, at €8), **Spain** (No. 4, at €7) and **Germany** (No. 6, at €6). **Cyprus** (No. 5, with €7), also does well, though it has relatively little domestic industry. By contrast, **Finland** (No. 25, at €2), **Latvia** (No. 26, at €2) and **Bulgaria** (No. 27, at €1.40) weigh in at the bottom of the list.[30]

Table 6: Service-Sector Energy Productivity Sub-Indicator

in euros of value added per cubic meter of natural gas equivalent

Rank	Country	Productivity
1	United Kingdom	43
2	Ireland	42
3	Denmark	37
4	France	35
5	Austria	34
6	Luxembourg	34
	European Union 27	31
7	Germany	31
8	Malta*	31
9	Greece	31
10	Italy	29
11	Spain	28
12	Netherlands	27
13	Belgium	27
14	Sweden	26
15	Portugal	24
16	Norway	21
17	Cyprus	21
18	Slovenia	18
19	Finland	17
20	Romania	14
21	Lithuania	13
22	Czech Rep.	12
23	Poland	11
24	Hungary*	10
25	Latvia	10
26	Estonia*	9
27	Slovakia*	7
28	Bulgaria	7

* value for 2010
Source: Enerdata/Ecofys analysis

30 Bulgaria and Finland are improving rapidly, as we shall see in the Improvement in Energy Productivity for Industry Sub-indicator.

'Countries can set a high standard for industrial development and energy productivity at the same time.'

Table 7: Service Sector Energy Productivity Growth Sub-Indicator

in euros of value added per cubic meter of natural gas equivalent

Rank	Country	Growth
1	Romania	4,90%
2	Slovenia	3,11%
3	Slovakia*	3,10%
4	United Kingdom	3,07%
5	Luxembourg	3,06%
6	Latvia	2,18%
7	Bulgaria	2,15%
8	Sweden	2,02%
9	Malta*	1,92%
10	Czech Republic	1,84%
11	Austria	1,59%
12	Ireland	1,52%
13	Germany	1,30%
14	Norway	1,01%
15	Hungary*	0,99%
16	Lithuania	0,65%
17	Cyprus	0,28%
	European Union 27	0,24%
18	Denmark	0,18%
19	Portugal	-0,13%
20	Netherlands	-0,41%
21	France	-0,67%
22	Greece	-0,68%
23	Belgium	-0,80%
24	Finland	-0,95%
25	Poland	-1,06%
26	Spain	-1,50%
27	Estonia*	-2,05%
28	Italy	-2,62%

* growth over the 2001-2010 period
Source: Enerdata/Ecofys analysis

Table 9 The **Improvement in Energy Productivity for Industry Sub-Indicator** tells an equally interesting story on page 22. Once again, we see the "catch-up" countries improving quickly with **Slovakia** (No. 1, at 8.7% average annual improvement over a ten-year period), **Romania** (No. 2, at 6.2% average annual improvement), **Czech Republic** (No. 3 at 5.7%) and **Poland** (No. 4, at 5.5%), **Bulgaria** (No. 5, at 4.4%) and **Estonia** (No. 6, at 3.4%) all running well ahead of the **EU average** of 1.5%. **Sweden** (No. 7, at 3.3%) also fares well, showing that this environmentally-conscious country continues to find ways to make its overall energy performance even more effective. **Belgium** and **United Kingdom** (No 13 and No. 14, at 2.0%), **Spain** (No. 15 at 1.8%) and the **Netherlands** (No. 16 at 1.6%) also do relatively well, weighing in just above the EU average. By contrast, four European countries actually registered no growth or negative energy-productivity growth in the industrial sector: **Austria** (No. 24, at just below 0%), **Luxembourg** (No. 25, at -1.0%) and **Portugal** (No. 26, at -1.2%) and **Malta** (No. 27, at - 2.5%).

Overall, European industry is improving rather well. But it is important this progress continues. And, as we saw in the Improvement in Energy Productivity for Industry Sub-Indicator, the advances should be spread more evenly throughout the EU. It is not enough for environmentally friendly countries like Sweden or the EU catch-up countries to pull all of the weight for the EU average. An improvement of at least 1% per year can be attained by industry in all EU countries and is needed for the benefits to be truly felt and the social advances of reduced energy costs truly met.

‘The vast burden of bettering the global energy consumption performance most certainly lies with the world’s largest economies.’

Table 8: Resource Productivity in Industry Sub-Indicator

in euros of GDP produced per cubic meter of natural gas equivalent consumed

Rank	Country	Productivity
1	Ireland	11,1
2	Denmark	10,6
3	United Kingdom	7,9
4	Spain	7,0
5	Cyprus	6,8
6	Germany	6,5
7	Malta*	6,4
8	Austria	6,0
9	France	6,0
	European Union 27	6,0
10	Italy	5,9
11	Netherlands	5,6
12	Lithuania	5,1
13	Greece	5,0
14	Hungary*	5,0
15	Poland	4,5
16	Slovenia	4,2
17	Portugal	4,0
18	Belgium	4,0
19	Sweden	4,0
20	Czech Republic	3,6
21	Slovakia*	3,3
22	Estonia*	3,2
23	Romania	3,1
24	Luxembourg	3,0
25	Finland	2,4
26	Latvia	2,4
27	Bulgaria	1,4

* values refer to 2010
Source: Enerdata/Ecofys analysis

Table 9: Improvement in Resource Productivity for Industry Sub-Indicator

Underlying figures based on euros of GDP produced per cubic meter of natural gas equivalent consumed (2001-2011)

Rank	Country	Growth
1	Slovakia*	8,73%
2	Romania	6,24%
3	Czech Republic	5,67%
4	Poland	5,53%
5	Bulgaria	4,37%
6	Estonia*	3,39%
7	Sweden	3,33%
8	Lithuania	2,78%
9	Slovenia	2,66%
10	Finland	2,42%
11	Hungary*	2,39%
12	Cyprus	2,21%
13	Belgium	2,04%
14	United Kingdom	2,02%
15	Spain	1,78%
16	Netherlands	1,62%
	European Union 27	1,50%
17	Italy	1,23%
18	France	1,05%
19	Denmark	0,55%
20	Greece	0,41%
21	Ireland	0,34%
22	Latvia	0,29%
23	Germany	0,01%
24	Austria	-0,30%
25	Luxembourg	-0,97%
26	Portugal	-1,16%
27	Malta*	-2,50%

* growth over the 2001-2010 period
Source: Enerdata/Ecofys analysis

‘The world’s largest economies were able to produce on average 18% more GDP in the last 10 years thanks to the energy savings they have already made.’

Refrigerators: an energy-labelling success story

Between 1973 and 2014, the energy productivity of typical refrigerators used in households rose by a factor of almost six. These improvements were mainly driven by the introduction of energy labelling systems that were implemented in many countries, including the United States and the European Union. Households can now understand the energy and cost implications of the purchases they are considering. But the system itself has become crowded at the top, and recent efforts to improve efficiency have become more difficult to translate into easy-to-understand figures. For example: under the revised (2010) European Union labelling scheme, consumers can see quickly that a label A refrigerator is two times more energy efficient than a label D device. But they don’t always know these days label A indicates a relatively poor performance. Label A+++ appliances, for example, which are already on the market, use less than half the energy of a label A device. For the moment, there is no schedule for revising standards upwards for new refrigerators so the current slightly out-of-date system will likely remain in place for the foreseeable future.

Refrigerator energy productivity

Liters cooled per 1000 kWh

Development of energy productivity of refrigerators[1] (Loy, 2013) (Energieweter.nl, 2014).

[1] The volume of the refrigerators varied between 429 - 510 liters (Energieweter.nl, 2014) (Loy, 2013)

‘In the European Union, improving energy efficiency helped facilitate an additional 17% of economic growth at the same level of energy consumption in the last decade.’

Part III. Country Studies and Roadmaps

III.1 European Union

Based on its current trajectory – and with the current rules and systems in place – Europe could easily enjoy an economic expansion of 35% between now and 2030 while meeting its annual energy needs that year at approximately the same level as today.[31] In the Business-As-Usual Scenario we developed, Europe will consume roughly 45 exajoules of energy per year in 2030, down from 46 exajoules in 2012.[32] This will be no mean feat as the population (as the EU-27 is currently configured) is set to rise to 520 million in 2030, up from 503 in 2014. And GDP is forecast to rise to €17.8 trillion, up from €13.3 trillion in 2012. See the full energy, economy and population projection in the EU-27 High Energy Productivity Growth Overview on page 34 for more.[33]

So merely holding energy consumption at the current level while the economy expands would be a welcome development in and of itself. But it is not enough. A rising global population – and accelerating global economy, driven mostly by the economic development in the developing world – imply that we must set our ambitions even higher. The United Nations, for one, has called for a doubling of the rate of improvement in energy productivity on a global level by 2030, arguing that it is only with an increase of this size that we will be able to curb climate change and allow the world enough wiggle room to accommodate the economic and population growth expected in that time.[35] The European Union also vowed in a 2014 decision to reduce energy demand by 27% or more from the projected level of energy consumption in 2030.[36]

The good news is that these visions are not pipe dreams. We can do this already with existing technologies. Under the High-Energy Productivity Growth Scenario – which is based on more aggressive roll-out of existing energy-saving technologies – we believe Europe could cut its final energy consumption to 30 exajoules per year, down from the

31 The modelling in this section is based on the EU-27 countries, so Croatia was not yet included. This has a small impact on the overall results: With a population of four million it has a primary energy consumption of 0.35 exajoules.

32 The Business-As-Usual Scenario is based on developments that are outlined in European Commission, *EU Energy, Transport and GHG Emissions Trends to 2050* (Brussels: European Commission, 2013) for all European member states and for the EU-27. The scenarios were modelled with the PRIMES Model and take into account the impact of existing policies, the latest economic outlooks and demographic developments. Because not all input data of the scenarios were available, assumptions had to be made to translate them to scenarios in the Energy Transition Model, e.g., on the used heating technologies in the different sectors. Because the Energy Transition Model is based on IEA statistics and PRIMES is not, absolute numbers might differ. The annual demand changes in percent per sector are aligned within 0.1%-point. The annual growth rates per fuel differ in some cases (up to 1% point) because the way the energy sector is modelled in the Energy Transition Model is different from the way it is done in PRIMES. The High Energy-Productivity Growth Scenarios assume the same economic and demographic developments; this means that the same demand for heat, light, appliance output, services and products is met. The only difference is that the demand is met with more efficient technologies. For more, visit www.energytransitionmodel.com.

33 Eurostat, *Population on 01 January 2014* (Luxembourg: Eurostat, 2014).

34 Interested readers can also view interactive versions of the scenarios presented in this paper, programme in their own modelling assumptions and see the results. For the EU-27 High Energy Productivity Growth Scenario, visit http://pro.et-model.com/scenarios/363836. For the EU-27 Business-As-Usual Scenario, visit http://pro.et.model.com/scenarios/363781. Results might differ slightly from the figures provided in this report because the online model is continuously refined.

35 A doubling for Europe would imply a growth in productivity of 3.6% per year until 2030: the average improvement rate between 1990 and 2011 was 1.8%. For Europe, this is close to but below the High Energy-Productivity Growth scenario we will present in these pages. This means the UN goal is well within Europe’s grasp.

36 European Council, *European Council (23 and 24 October) Conclusions* (Brussels: European Council, 2014). To reach the 27% goal, the European Commission uses a reference scenario that dates from before the start of the financial crisis. Compared to the Business-As-Usual Scenario developed in this study, the EU would only need to secure an 8% reduction on current trend to reach this target.

Passenger cars: getting better and better

Over the past 40 years, the basic energy productivity of cars has improved significantly. In the early 1970s in the United States, the average passenger car had a fuel efficiency of 5.6 kilometres per litre. Today, the US average has nearly doubled to 11 kilometres per litre.

One of the drivers for this improvement was the 1973 oil crises. The higher, unstable oil prices changed consumer behaviour and triggered action, such as expanding R&D efforts to develop more efficient technologies and the implementation of fuel economy standards. In 1975, the US Energy Policy Conservation Act was put forward, mandating that new passenger cars should have a minimum fuel economy standard of 18.0 miles per gallon (7.6 kilometres/litre) by 1978, improving to 27.5 miles per gallon (11.7 kilometres/litre) by 1985. After 1985, the standard remained almost unchanged until 2011. The current standards oblige new US passenger cars to have a fuel efficiency of 23.3 kilometres/litre in 2025, which would be another doubling of energy productivity in 10 years.

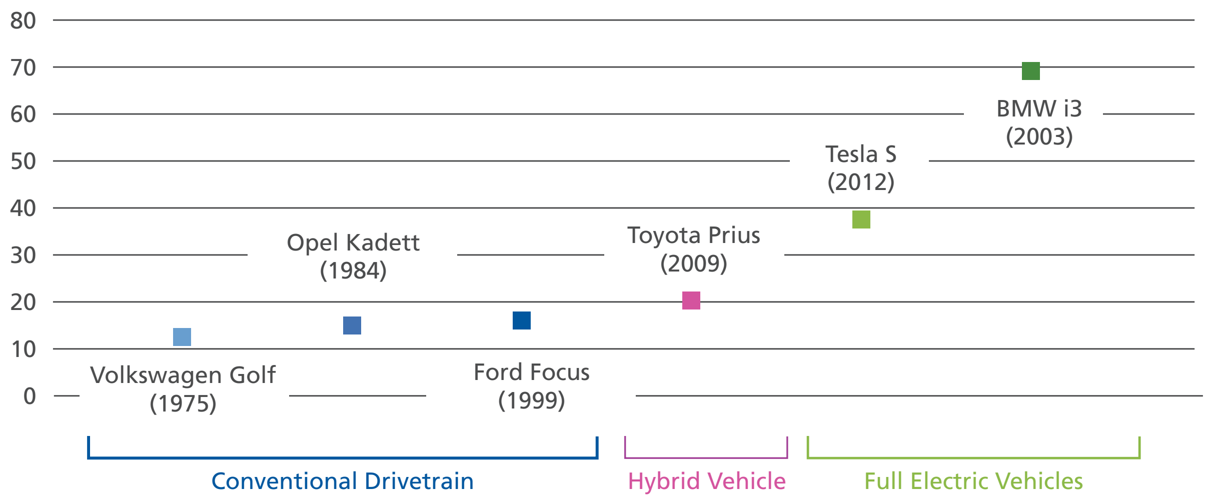
Fuel efficiency standards have also been implemented in Europe, Japan, South-Korea, China and many other countries. In the European Union, mandatory CO2 emission performance standards for new cars were introduced in 2009. The regulation set the CO2 standard for 2015 on 130 gCO_2/kilometre and for 2020 on 95 gCO_2/kilometres. In terms of energy efficiency, this means an average performance of about 18 kilometres/litre gasoline in 2015 and 25 kilometres/litre gasoline in 2020.

The table below shows the improvement in fuel efficiency over the years. Energy productivity of passenger cars with conventional drivetrains is still increasing, but additional improvement is being made with alternative drivetrains, such as hybrids (including plug-in hybrids) and full electric vehicles. Next to improvements in the drivetrain, a decrease of weight and improved aerodynamics increases the energy productivity of passenger cars significantly.

In the High-Energy Productivity Growth Scenario developed in this paper, the efficiency of an average car (including electric cars) should increase to around 29 kilometres/litre, up from 14 kilometres/litre.

Passenger cars energy productivity

kilometers / liter gasoline



Improvement in fuel productivity of different car types. Electricity consumption by electric vehicles is converted to gasoline equivalents (final energy consumption) (Automobile-catalog, 2014) (US DOE, 2014) (BMW, 2014)

‘The overall investment involved would be substantially less than the cost of fuel that would have been spent had the investment not been made.’

46 exajoules consumed annually today – a 35% reduction. And the process itself – while it will surely incur initial investment costs – would be immensely beneficial to society at large. Apart from its evidently positive effects on the environment, it would bring down the overall costs of growing the economic and re-arranging our economic life around more fulfilling goals – for governments and individuals alike. Money would be freed up for spending in other areas, such as health, entertainment, shoring up pension systems, retiring debt and more. Together, Ecofys and Quintel have calculated that the overall investment involved would be substantially less than the cost of fuel that would have been spent had the investment not been made.[37]

Under the Business-as-Usual Scenario, Europe will spend around €440 billion on imports for fossil fuels per year in 2030. Under the High Energy Productivity Growth Scenario, that figure falls to €270 billion, a reduction of €170 billion per year, which amounts to a savings per household of around €750. Significantly, this would not be a one-off savings, but an annual windfall.

The premise that we can do this, however, is based on two important assumptions: first and foremost, it implies that Europeans are ready to invest heavily in buildings where a doubling of the annual rate of energy productivity improvements is needed.[38] Specifically, we need to revamp our existing infrastructure to give us state-of-the-possible energy conservation standards throughout our society. The goal would be to dramatically raise the energy efficiency of all buildings – professional and residential – at a pace roughly twice as much as they are improving today. And the good news is there are already technologies which are ready to deploy that would give us the scope and scale we need to reach these targets. Technology has advanced dramatically in recent years, with many new products now able to deliver considerably better energy performance, including highly-efficient lighting (see the box on Lighting: A Revolution in the Making on page 18 for more); insulation and heat pumps (see the box on Warmer Households: A Breakthrough at Hand on page 17); and other appliances (see the box on Refrigerators: An Energy Labelling Success Story on page 25). We calculate that – by more aggressively deploying advanced lighting, insulation and heat pumps throughout our houses and buildings – Europe could halve the amount of energy being consumed in buildings, taking the total amount of energy consumed in residential buildings to 5.4 exajoules a year in 2030, down from 11.5 in 2012 (a 53% drop).[39] For non-residential buildings and agriculture, the 2030 figure would be 3.3 exajoules per year under the High-Energy Productivity Growth Scenario, down from 6.8 exajoules today (a 51.5% improvement).[40] The savings involved would mean average annual energy demand reductions of 4.2% by 2030 for residential buildings and 3.9% for non-residential and agriculture.[41]

37 In the High Energy Productivity Scenario, the total spending on energy (including investment, maintenance and fuel) is 10% lower than in the Business-As-Usual Scenario. The composition of the European fuel bill also changes: in the Business-As-Usual Scenario, about 60% of the total energy costs constitute of fuel costs. In the High Energy Productivity Growth Scenario, only 45% of energy costs are fuel bills and relatively more is invested in efficient technologies.

38 Industry, by contrast, is hugely diverse and the energy efficiency potential in known is less detail. However, under the Business-As-Usual Scenario, we believe industry would see a slight rise in energy consumption of around 0.2% per annum through 2030. Under our High Energy Productivity Growth Scenario, industry would need to deliver energy efficiency savings of 0.8%, less than 1.0%, per year.

39 In the Business-As-Usual Scenario, the equivalent of 1000 m3 natural gas will heat a little over one household. In the High Energy Productivity Growth Scenario, two-and-a-half households can be heated with the same amount of energy.

40 The High Energy Productivity Growth Scenario posits a tripling of the average performance of existing buildings, along with a rapid deployment of advanced heat pumps, which would deliver 30% of the heat in 2030 under the scenario.

'Industry in Europe is already moderately energy efficient – perhaps due to the continent's relative energy dependence and the high cost of energy in many manufacturing–based countries.'

In the remainder of this section, we will look at the High Energy-Productivity Growth Scenario in six countries (France, Germany, Netherlands, Poland, Spain and the United Kingdom). What would each country need to do to deliver energy productivity improvements – and the consequent growth-enhancing reduction in overall energy consumption – consistent with the UN goals and the High Energy Productivity Growth Scenario presented in this paper? Given the technology we possess, and the starting point of each of these economies – both structurally, and in terms of the amount of energy they consume today – what do they need to do concretely to deliver the overall doubling of energy productivity by 2030 which the High Energy Productivity Growth Scenario implies?

III.2 France

France is a prosperous country with a relatively benign demographic outlook. Unlike many European countries, the French still have enough babies each year to successfully sustain the population at current levels without recourse to immigration. As a result, the population of metropolitan France is set to expand to 68.2 million by 2030, up from 63.9 million in 2014. Its energy outlook is relatively low-carbon as well – with nearly three-quarters of its electricity needs today being met through nuclear energy. See the full energy, economy and population projection in the France High Energy Productivity Growth Overview on page 36 for more.[42]

France's energy outlook is improving as well. On a Business-As-Usual Scenario trajectory, which includes improvements and policies already implemented, France's final energy use is projected to decline on average 0.3% per year by 2030 even with projected annual economic growth and a rising population. But France could do considerably better than this. Under the High-Energy Productivity Growth Scenario, French energy consumption could decrease by an annual average of 2.1% per year by 2030, bringing untold benefits to society at large, helping the government restore fiscal rectitude and freeing up large amounts of money for socially and economically beneficial investment.

To reach this goal, France would need to make substantial improvements in residential and non-residential building energy productivity, using better insulated building materials and more energy efficient appliances (including lighting) to decrease the amount of energy consumed by as much as 3.4% per year on average in these sectors, compared to the 0.7% fall in growth expected in the Business-As-Usual Scenario (the estimate is based on realistic assumptions regarding existing technology and actual French energy use today). With an already relatively high electrification rate of heating in buildings, France is well-equipped to make the transformation to heat pumps.

Under the Business-As-Usual Scenario, French industry will use roughly 0.4% more energy per year; the High-Energy Productivity Scenario would see that figure fall to -0.7% annual decline, reversing the trend. The transport sector as well could also substantially improve its performance, increasing annual energy savings to around 1.5% per annum, up from the 0.3% reduction expected under the Business-As-Usual Scenario.

41 Transport would be expected to double its energy efficiency improvements as well – a large move, but roughly in line with current improvements being implemented through rising auto emission standards. For more, see the box on Passenger Cars: Getting Better and Better on page 25.

42 For the France High Energy Productivity Growth Scenario, visit http://pro.et-model.com/scenarios/363839. For the France Business-As-Usual Scenario, visit http://pro.et-model.com/scenarios/363831. Results might differ slightly from the figures provided in this report because the online model is continuously refined.

'Overall European industry is improving rather well. But it is important that this progress continues.'

In the High-Energy Productivity Growth Scenario, France will also continue shifting away from coal and gas (with declines of 4.5 and 2.8% per year, respectively) – a development which would only require a slight improvement on current trend. The rate of adopting renewable energy should continue to rise. As the use of other types of energy declines, renewable energy should become a more important component of the domestic energy mix even as the overall amount of energy consumed (including from renewables) declines.

III.3 Germany

Under the Business-As-Usual Scenario, Germany has one of Europe's best energy outlooks. Its energy productivity – even if nothing changes – is set to increase by an annual average of 2.4% – the result of a major effort already underway to make energy use more efficient and increase the consumption of renewables. Its declining population also contributes to Germany's drop in energy consumption. On current trend, the population is actually projected to shrink, falling to 77.9 million people by 2030, down from 80.8 million in 2014. For more, see the full energy, economy and population projection in the Germany High Energy Productivity Growth Overview on page 38.[43]

However, Germany can do even better on energy. Under the High-Energy Productivity Growth scenario – based on Germany's actual energy use today – the country could decrease its annual final energy consumption by as much as 32% by 2030 through more aggressive use of existing technology, bringing down the amount of energy consumed in residential buildings by 4.4% on average each year (the figure for non-residential buildings would be a 5.0% annual average), up from a 0.8 and 1.4% annual decrease in the Business-As-Usual Scenario. In Germany, the contribution of manufacturing to the economy is relatively large. In Europe, industry generates about 15% of GDP. But in Germany, industry contributes nearly 21%. Moreover, thanks to the country's immense success in this area, this is set to rise. By 2030, industry will account for the lion's share of German energy use, replacing buildings, which leads today. This puts a special burden on German industry to continue improving in the energy-efficiency arena if Germany wants to remain an energy-efficiency leader overall.

Within industry, engineering is by far the largest subsector in terms of economic value added. However in terms of energy demand, the chemical sector is the largest user – so this is where Germany might need to focus its energy-efficiency efforts. Among the steps that would improve energy efficiency in the chemical industry could be increased use of combined heat and power and more efficient use of heat, for example by better using waste-heat. As industrial activities are very diverse, the possibilities to improve energy efficiency will vary from installation to installation.

As in France, Germany continues shifting away from coal, oil and gas in the High Energy Productivity Growth Scenario (with declines of 4.4%, 3.0% and 2.4% per year, respectively) – a development which would only require a slight improvement on current trend. The rate of adopting renewable energy should continue to rise. As in France, renewable energy should become a more

43 For the Germany High Energy Productivity Growth Scenario, visit http://pro.et-model.com/scenarios/363850. For the Germany Business-As-Usual Scenario, visit http://pro.et-model.com/scenarios/363816. Results might differ slightly from the figures provided in this report because the online model is continuously refined.

‘Merely holding energy consumption at the current level while the economy expands would be a welcome development in and of itself. But it is not enough.’

important component of the domestic energy mix as the use of other types of energy declines, even as the overall amount of energy consumed (including from renewables) declines.

III.4 Netherlands

The Netherlands scores well on energy productivity. In the **Energy Productivity of Households Sub-Indicator,** it was ranked No. 5 with a relatively strong performance at the top of the European league table. But there is still scope for improvement in this medium-sized industrial and services powerhouse. Specifically, we calculate that the Netherlands could trim its overall final energy use to 1.3 exajoules by 2030, down from 2.1 exajoules in 2012 – a 38% improvement. This would take place despite a forecasted rise in the population to 17.6 million, up from 16.8 million in 2014, and projected GDP growth of 31% over the same periods (with a 2030 forecast GDP of €737 billion, up from €563 billion in 2012). See the full energy, economy and population projection in the Netherlands High Energy Productivity Growth Overview on page 40 for more.[44]

As in most countries, the main improvement would come from a dramatic increase in the energy productivity of housing and buildings. Under the Business-As-Usual Scenario, Dutch houses and non-commercial buildings would essentially remain as efficient as they are today, with a small increase in household energy use and a small annual average decline of 0.3% for commercial buildings. Under the High Energy-Productivity Growth Scenario, energy consumption in residential buildings and non-commercial buildings would fall annually by 3.5% and 3%, respectively. This would require improvements in building insulation and an increased deployment of heat pumps, moving the heating of Dutch buildings away from natural gas. Buildings of all types will remain the largest energy consumer in the Netherlands, followed by industry. In terms of energy demand, chemicals is the largest industrial sector. Greater re-use of heat and an increase in utilisation of combined heat and power in that sector would be important energy saving measures. Additionally, the re-use of materials and prevention of waste production could be used to save additional energy.

In the High-Energy Productivity Growth Scenario, Dutch demand for fossil fuel would decline a bit faster than in the Business-As-Usual Scenario, while renewable energy growth rates could even be a bit lower than they are today and still make up a considerably higher share of the overall energy picture. Under the High-Energy Productivity Growth Scenario, which is based on a realistic reduction from existing levels, natural gas should experience the most dramatic reduction in demand, falling at around 3% per year. This would be sufficient to compensate the expected decline of Dutch natural gas production and prevent the need to import natural gas (which would be necessary under the Business-As-Usual Scenario).

44 For the Netherlands High Energy Productivity Growth Scenario, visit http://pro.et-model.com/scenarios/363845. For the Netherlands Business-As-Usual Scenario, visit http://pro.et-model.com/scenarios/363119. Results might differ slightly from the figures provided in this report because the online model is continuously refined.

‘The difference between the High Energy Productivity Growth and the Business-As-Usual scenarios for Poland is the difference between success and failure.’

III.5 Poland

The Polish economy is set to continue growing with dramatic growth in GDP between 2012 (€676 billion) and 2030 (€1.011 trillion forecast on current trend). Perhaps because of this projected growth, Poland seems likely to defy the overall European trend, looking like it will be consuming more energy in 2030 than it does today. Under the Business-As-Usual Scenario, annual Polish final energy consumption will rise to 3.1 exajoules in 2030, up from 2.7 exajoules in 2012. Along with Spain, it is one of the few European countries that is expected to show a significant increase in energy demand. Under the Business-As-Usual Scenario, Polish energy use will likely increase at around 0.9% per year on current trend. This is to a large extent driven by an increase in industrial activity, the added value of which is projected to increase around 2.9% per year, resulting in an average annual rise in industrial energy use of 1.6%. For more, see the full energy, economy and population projection in the EU-27 High Energy Productivity Growth Overview on page 42.[45]

But even with projected economic and industrial growth on this scale, Poland can still reach a 34% reduction in final energy use (compared to the Business-As-Usual Scenario) under the High Energy-Productivity Growth Scenario. Under the High Energy Productivity Growth Scenario, residential and non-residential buildings would need to improve at 3.6% and 3.0% annual averages. But industry would have to cut its rise in annual energy use by roughly two-thirds by year – keeping the rise to a roughly 0.6% average annual growth, down from the projected 1.6% under the Business-as-Usual Scenario.

In the High-Energy Productivity Growth Scenario, coal demand should decline the fastest, falling around 2% per year. But Poland’s gas demand under the Business-As-Usual Scenario is also high. To reach the doubling of energy productivity in the High Energy Productivity Growth Scenario, Polish natural gas demand could be mitigated most dramatically – turning the increasing annual demand into a 1% annual decline. As elsewhere, renewable energy should become a larger part of a smaller pie, meaning the growth in the use of renewables could actually decline on current use so long as the overall energy usage declined more quickly.

Unlike other European countries, the difference between the Business-As-Usual Scenario and High-Energy Productivity Growth Scenario for Poland is the difference between success and failure. If Poland stays on the Business-As-Usual Scenario, it will be paying more for energy bills in 2030 than it does today, with a corresponding decline in living standards, international competitiveness, quality of public finance and more. By contrast, the High Energy-Productivity Scenario would take Poland to a better position, representing a 34% improvement on the projected level in 2030.

III.6 Spain

The Spanish economy has seen better times. Beset with a sky-high unemployment rate of 24% – with youth unemployment of 54% – the country also suffers from a prolonged period of chronic underinvestment in key technologies, including energy-saving technologies.[46] Under the current Business-As-Usual Scenario, energy use in Spain is set to increase by roughly 0.6% per annum, driven

45 For the Poland High Energy Productivity Growth Scenario, visit http://pro.et-model.com/scenarios/363852. For the Poland Business-As-Usual Scenario, visit http://pro.et-model.com/scenarios/363802. Results might differ slightly from the figures provided in this report because the online model is continuously refined.

46 The Spanish unemployment figures are for August 2014. See Eurostat, *Newsrelease: Euroindicators* 146/2014 30 September 2014 (Luxembourg: Eurostat, 2014).

'The United Nations has called for doubling of the rate of energy productivity on a global level by 2030, arguing that it is only with an increase of this size that we will be able to curb climate change.'

by a relatively high economic growth as the country gets back to its former path. This means that if Spain stays on its current course, it will likely see total final energy consumption rise to as much as 4.0 exajoules in 2030, up from 3.6 exajoules in 2012. See the full energy, economy and population projection in the Spain High Energy Productivity Growth Overview on page 44 for more.[47]

The good news is the Spanish economy could prosper while still reducing its energy needs, delivering a 27% energy reduction compared to the Business-As-Usual Scenario. Under that scenario, energy savings in buildings would need to rise 3% per year more than in the Business-As-Usual Scenario (this is achievable, even though the effects of building insulation are slightly lower than in colder regions). Under the Business-As-Usual Scenario, transport and industry remain the largest energy consumers. But under the High Energy Productivity Growth Scenario, transport improves around 1% a year, leaving industrial activities as the highest consumer. Even then, industry could reduce its energy demand by nearly 1% per year while growing its added value with nearly 2% annually.

In the High Energy Productivity Growth Scenario, the demand for fossil fuel declines faster than in the Business-As-Usual Scenario. Coal demand could experience the fastest decline, nearly 4% per year. This would have a hugely positive impact on emission reductions, but also on public health. As in other countries, the trend in increasing natural gas consumption needs to be reversed. And renewables should take a larger part of the overall energy pie, even if that pie is a smaller one based on conservation across the board.

Spain, currently in a prolonged economic crisis, could benefit hugely from energy efficiency. Investments in energy efficiency create domestic jobs. And, as Spain imports most of its energy, it would reduce the country's dependence on external supply – and lower its bills to other countries. The money saved on foreign fuel could be spent domestically on other goods and services – including investment. Furthermore, reduced import dependency would make Spain less sensitive to international fuel price developments. This means that in case fuel prices increase, economic growth would be slowed down to a lesser extent. And, finally energy efficiency measures would help Spain achieve higher renewable energy shares by 2030 at the same – or even lower – level of investments.

III.7 United Kingdom

The United Kingdom has a huge advantage. It boasts one of Europe's largest and most developed service sectors, which as a rule carries a lighter energy footprint than more industry-dependent economies. Under the Business-As-Usual Scenario, the UK economy is projected to grow to €2,471 billion in 2030, up from €1,748 billion in 2012, a 43% rise. But we believe the UK could simultaneously deliver a massively improved energy-dependency figure at the same time. Specifically, we think the UK economy could lower its energy use to around 3.5 exajoules in 2030, down from 5.4 exajoules in 2012. For more, see the full energy, economy and population projection in the UK High Energy Productivity Growth Overview on page 46 for more.[48]

47 For the Spain High Energy Productivity Growth Scenario, visit http://pro.et-model.com/scenarios/363842. For the Spain Business-As-Usual Scenario, visit http://pro.et-model.com/scenarios/363828. Results might differ slightly from the figures provided in this report because the online model is continuously refined.

48 For the UK High Energy Productivity Growth Scenario, visit http://pro.et-model.com/scenarios/363847. For the UK Business-As-Usual Scenario, visit http://pro.et-model.com/scenarios/363789. Results might differ slightly from the figures provided in this report because the online model is continuously refined.

‘The European Union also vowed to reduce energy demand by 27% or more from the projected level of energy consumption in 2030.’

The move would require aggressive action to improve the energy efficiency of residential buildings. Currently, energy demand in residential buildings alone is responsible for the highest energy demand across all sectors. Energy demand in buildings could be halved compared to 2012, first of all by renovating existing buildings and improving the performance there by a factor three. Next to this the service sector, where most growth in added value is projected, could further increase its energy productivity by deploying the most efficient appliances and lighting in all-service related buildings.

In the High-Energy Productivity Growth Scenario, the UK demand for fossil fuel declines faster than in the Business-As-Usual Scenario. Coal demand will experience the fastest decline (11% annually), but this fuel also has a rapidly declining share in the UK’s Business-As-Usual Scenario as well (10% annually). While natural gas demand increases in the Business-As-Usual Scenario, it declines in the High-Energy Productivity Growth Scenario. Since the UK will most likely experience a declining natural gas production, mitigating natural gas demand is a very important strategy to moderate its energy dependency.

Part IV. Conclusions and Policy Recommendations

The vision laid out in this paper is realistic and achievable. But how do we get there? History teaches that there are three principal levers driving forward change in the energy field: 1) the level of regulation to enforce standards and increase consumer transparency, 2) the cost of energy to stimulate or dampen supply and demand, and 3) the cost of technology to improve energy usage. Any effort to drive forward change in the field of energy usage will need to be based on skilful manipulation of at least one if not all three of these levers.

Perhaps the best way to distil this complex economic picture into a set of concrete policy recommendations would be to remember which areas offer Europe – and European policymakers – the most hope for progress. As we saw in Part III, industry in Europe is relatively efficient; under the High Energy Productivity Growth Scenario we have developed in this paper, it need only continue delivering annual energy productivity improvements roughly in line with those that it is already delivering today.

The most palpable gains are to be made by doubling the energy efficiency of residencies and non-commercial buildings. And here is where skilful use of the three-lever matrix comes in.

1. **Ambition.** Policymakers must set the ambition to improve. They must lead in a public policy context, taking time to explain why increased energy efficiency is a win-win-win proposition for citizens, business and governments alike. Political leaders must set ambitious goals. And they should give us workable roadmaps by which we can achieve them.[49] They must also make certain that, in an age of so many competing policy priorities, the role of increasing energy productivity is not allowed to disappear from the front-rung of policymaking. People need to understand why this is important – and perhaps even to be reminded of that on an almost daily basis.[50]

2. **Regulation.** Consumers and businesses don’t like spending more money – even if the upside is saving more money tomorrow. The case of light bulbs is a good one. The market for high-end energy saving bulbs was moribund until the European Union mandated the phasing out of incandescent bulbs by 2012 – a goal which was considered ambitious at the time but has been achieved

49 Policymakers and progressive companies can also join forces, as is already happening in the Global Energy Efficiency Accelerator Platform and the UNEP en.lighten initiative. Visit www.se4all.org/energyefficiencyplatform and www.enlighten-initiative.org for more.

50 European regulation, such as Ecodesign (for energy using products), the Energy Efficiency Directive and the Energy Performance of Buildings Directive are examples of instruments (provided they continue to aim high) that contribute to achieving the ambitions set out in the High Energy Productivity Growth Scenario.

‘Europe could cut its final energy consumption to 30 exajoules per year, down from the 46 exajoules consumed annually today – a 35% reduction.’

in the main. The result was a relatively speedy transition within Europe, which may have already saved European consumers and taxpayers as much as €9 billion in running costs.[51] Political leaders must be prepared to deploy their regulatory tool kit, setting high but attainable energy standards for buildings and for household appliances. This goes especially for energy-efficient lighting, whose widespread deployment could bring us quickly forward in so many areas. Policymakers should use their power to regulate higher standards than those that exist today. And they should help consumers make the right choice by developing and enforcing advanced energy labelling, so consumers know the benefits of the new products and the shortcomings of the old.

3. **Revamp buildings.** Building codes should be set deliberately high, as is already done for new buildings. High energy-productivity standards should also be applied to old buildings, particularly at the point of sale to new agents. Energy audits should be required as part of the sale process, with tax incentives put in place to encourage the owners of old buildings to bring them up to the standards of the new. The energy audits should clearly show the savings to be realized from funding improvement in key areas. The initial upfront investment in energy-efficient lighting and state-of-the-art insulation will be more than paid for over the typical life cycle of the building. This needs to be made much more clear to consumers in the form of mandatory standards and increased transparency through labelling.

4. **Fund research.** We know a lot today. But we are destined to know even more tomorrow. Policymakers should continue to fund advanced research into energy-saving technologies on a broad basis. The breakthroughs in this area will more than offset the cost of the research now. Research should look not just at the “pure science” aspect of increasing energy productivity – though breakthroughs in this area will be important. It should also look at lowering the costs of deploying existing technology, and creating better mechanisms for insuring its diffusion. Particularly promising areas of research are super-insulating materials, high-performance and quickly-rechargeable batteries, cost-effective heat pump systems, breakthrough-efficient industrial processes and advanced monitoring and control systems.

Throughout this policy brief, we have argued that improved energy productivity is a win-win-win scenario, offering better outcomes for governments, businesses and citizens alike. The IEA estimates that – if energy efficiency could be increased by 13% by 2035, which is considerably less than the 30% by 2030 improvement in the High Energy Productivity Scenario developed here, GDP would be as much as 0.4 percentage points higher for the world and 1.1 percentage point in Europe.[52] And the investment alone – while considerable – would bring important benefits in its wake. Ecofys has calculated that taking the steps you would need to double energy efficiency could reduce the global fossil fuel bill by more than €2 trillion (compared to the Business-As-Usual Scenario). Moreover, this would create more than six million jobs globally by 2020, net of any job losses in low-energy-intensity sectors.[53]

As with all social change, it will require vision, ambition and persistence to get there. Still, if the history of the modern world teaches us anything, it is that the society which gets there first will ultimately benefit the most.

51 Philips, *The LED Lighting Revolution: A Summary of the Global Savings Potential* (Eindhoven: Philips, 2012).
52 International Energy Agency, *World Energy Outlook 2012* (Paris: IEA, 2012).
53 See the box on Where Will the Jobs Come From? on page 48 for more on this point.

European Union

Annual economic growth (2010-2030)

+ 1.53%

Link: High Energy Productivity Growth Scenario

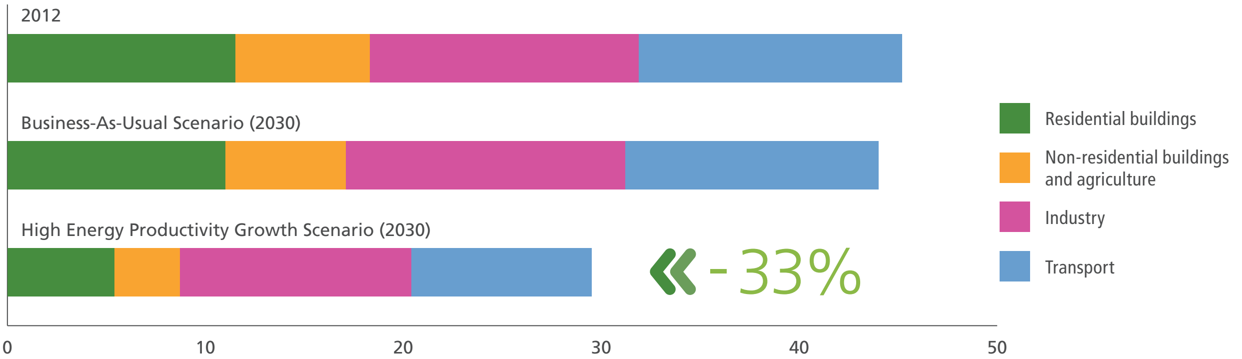
http://pro.et-model.com/scenarios/363836

Link: Business-As-Usual Scenario

http://pro.et-model.com/scenarios/363781

	2012	2030
Population (millions)	500.3	517.1
Household size	2.4	2.29
Number of households (millions)	208	226
GDP (in billions of euros)	13 332	17 825

Final energy consumption in the European Union in two scenarios (in exajoules)



Final energy consumption per sector (in exajoules)

Sector	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)	Business-As-Usual Scenario / Annual Growth in 2030	High Energy Productivity Growth Scenario /Annual Growth in 2030
Residential	11.5	11.0	5.4	-0.3%	-4.2%
Non-residential and agriculture	6.8	6.1	3.3	-0.6%	-3.9%
Industry	13.6	14.1	11.7	0.2%	-0.8%
Transport	13.3	12.8	9.1	-0.2%	-2.1%
Total excluding non energy use	46.0	44.7	30.1	-0.2%	-2.3%
Non-energy use	*4.3*	*4.5*	*4.5*	*0.3%*	*0.3%*

Primary energy consumption per carrier (in exajoules)

Energy carrier	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)	Business-As-Usual Scenario / Annual Growth in 2030	High Energy Productivity Growth Scenario / Annual Growth in 2030
Bio-fuels	4.7	7.1	4.9	2.3%	0.2%
Oil	23.4	20.2	15.0	-0.8%	-2.4%
Gas	17.2	16.6	9.1	-0.2%	-3.5%
Coal	11.2	7.1	5.6	-2.5%	-3.8%
Renewable electricity	1.9	4.7	4.5	5.1%	4.8%
Uranium	10.1	8.2	7.1	-1.1%	-1.9%
Total	**68.6**	**64.0**	**46.1**	**-0.4%**	**-2.2%**

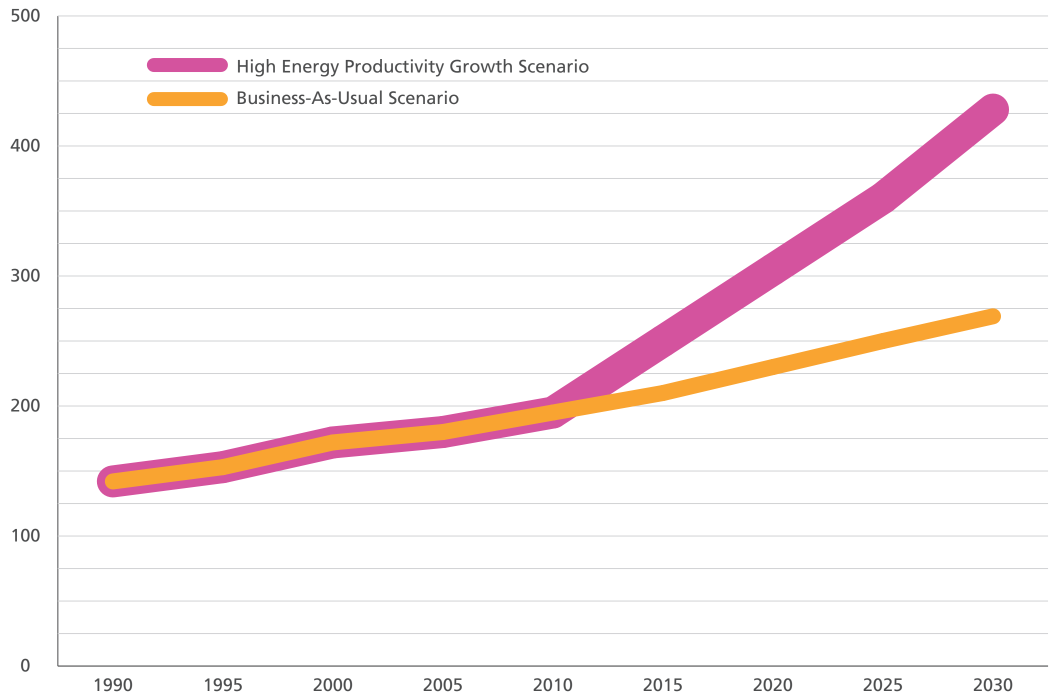
Final energy consumption per carrier, including non-energy use (in exajoules)

Energy carrier	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)	Business-As-Usual Scenario / Annual Growth in 2030	High Energy Productivity Growth Scenario / Annual Growth in 2030
Bio-fuels	2.8	3.7	2.3	1.6%	-1.2%
Oil	21.8	19.2	14.3	-0.7%	-2.3%
Gas	10.8	11.4	6.6	0.3%	-2.7%
Coal	1.6	1.1	0.9	-1.7%	-2.9%
Solar	0.1	0.1	0.1	1.1%	-1.3%
Geothermal	0.0	0.0	0.0	-0.4%	-0.4%
Electricity	10.4	10.9	8.6	0.3%	-1.1%
Hot water	2.8	2.7	1.8	-0.3%	-2.5%

Energy productivity (in billions of euros per exajoule of energy consumed)

	1990	1995	2000	2005	2010	2030	Average Annual Growth (1990-2010)	Average Annual Growth (2010-2030)
Business-As-Usual Scenario	142	153	172	180	195	269	1.6%	1.6%
High Energy Productivity Growth Scenario	142	153	172	180	195	428	1.6%	4.0%

The impact of energy productivity on GDP (in billions of euros per exajoule)



Energy consumption per household (in gigajoules)

	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)
Residential energy consumption per household	56	49	24

France

Annual economic growth (2010-2030)

+ 1.68%

Link: High Energy Productivity Growth Scenario

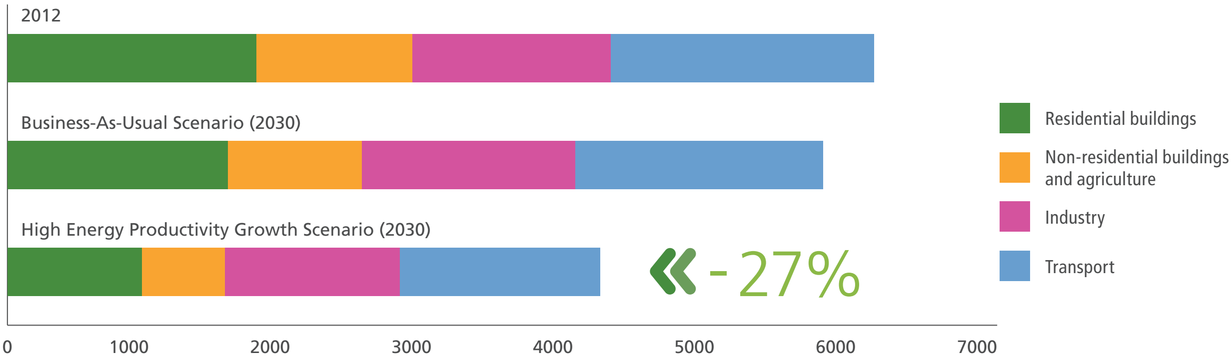
http://pro.et-model.com/scenarios/363839

Link: Business-As-Usual Scenario

http://pro.et-model.com/scenarios/363831

	2012	2030
Population (millions)	63.4	68.2
Household size	2.3	2.20
Number of households (millions)	28	31
GDP (in billions of euros)	1 877	2 568

Final energy consumption in France in two scenarios (in petajoules)



Final energy consumption per sector (in petajoules)

Sector	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)	Business-As-Usual Scenario / Annual Growth in 2030	High Energy Productivity Growth Scenario /Annual Growth in 2030
Residential	1 760.0	1 556.7	948.9	-0.7%	-3.4%
Non-residential and agriculture	1 103.7	949.9	589.2	-0.8%	-3.4%
Industry	1 402.0	1 506.7	1 236.8	0.4%	-0.7%
Transport	1 864.5	1 754.0	1 417.4	-0.3%	-1.5%
Total excluding non energy use	6 224.4	5 859.0	4 283.9	-0.3%	-2.1%
Non-energy use	*483.6*	*501.3*	*501.3*	*0.2%*	*0.2%*

Primary energy consumption per carrier (in petajoules)

Energy carrier	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)	Business-As-Usual Scenario / Annual Growth in 2030	High Energy Productivity Growth Scenario / Annual Growth in 2030
Bio-fuels	571.0	747.4	559.4	1.5%	-0.1%
Oil	3 248.1	2 795.2	2 196.3	-0.8%	-2.2%
Gas	1 530.5	1 391.3	919.4	-0.5%	-2.8%
Coal	440.6	234.6	191.7	-3.4%	-4.5%
Renewable electricity	258.1	730.9	690.1	6.0%	5.6%
Uranium	4 406.7	3 839.4	2 609.2	-0.8%	-2.9%
Total	**10 454.9**	**9 738.8**	**7 166.0**	**-0.4%**	**-2.1%**

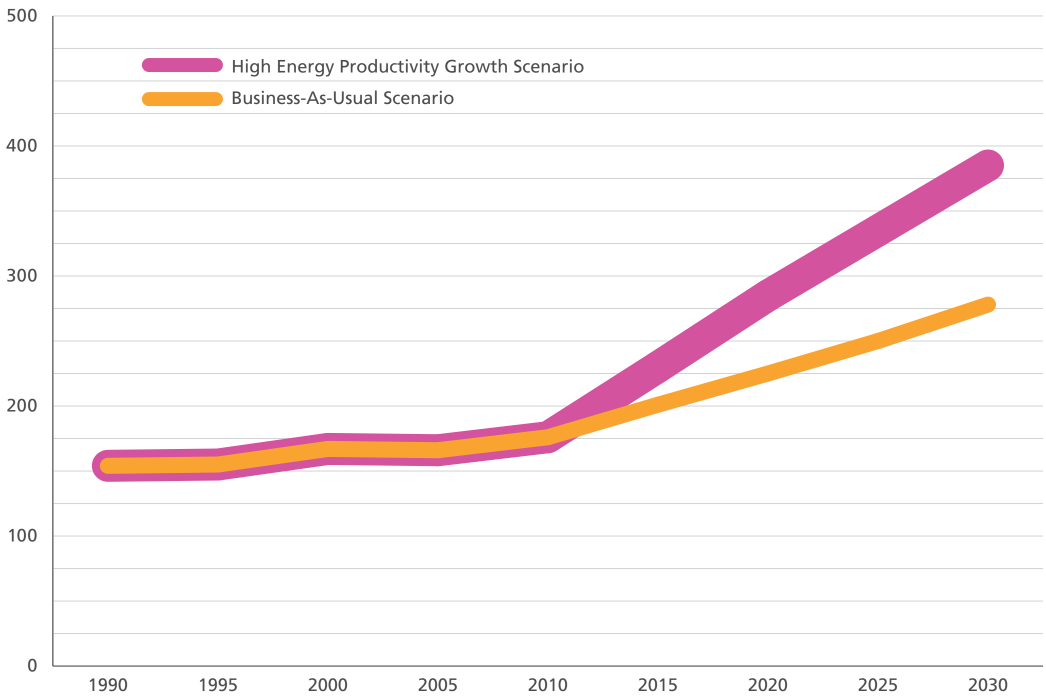
Final energy consumption per carrier, including non-energy use (in petajoules)

Energy carrier	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)	Business-As-Usual Scenario / Annual Growth in 2030	High Energy Productivity Growth Scenario / Annual Growth in 2030
Bio-fuels	472.7	482.3	308.7	0.1%	-2.3%
Oil	3 059.8	2 627.6	2 072.9	-0.8%	-2.1%
Gas	1 274.8	1 206.1	797.7	-0.3%	-2.6%
Coal	120.4	97.6	75.9	-1.2%	-2.5%
Solar	3.2	3.2	2.4	0.0%	-1.5%
Geothermal	0.8	0.7	0.7	-0.8%	-0.8%
Electricity	1 641.7	1 861.2	1 442.3	0.7%	-0.7%
Hot water	134.2	81.3	65.6	-2.7%	-3.9%

Energy productivity (in billions of euros per exajoule of energy consumed)

	1990	1995	2000	2005	2010	2030	Average Annual Growth (1990-2010)	Average Annual Growth (2010-2030)
Business-As-Usual Scenario	154	155	167	166	176	278	0.7%	2.3%
High Energy Productivity Growth Scenario	154	155	167	166	176	385	0.7%	4.0%

The impact of energy productivity on GDP (in billions of euros per exajoule)



Energy consumption per household (in gigajoules)

	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)
Residential energy consumption per household	64	50	31

Germany

Annual economic growth (2010-2030)

+0.96%

Link: High Energy Productivity Growth Scenario

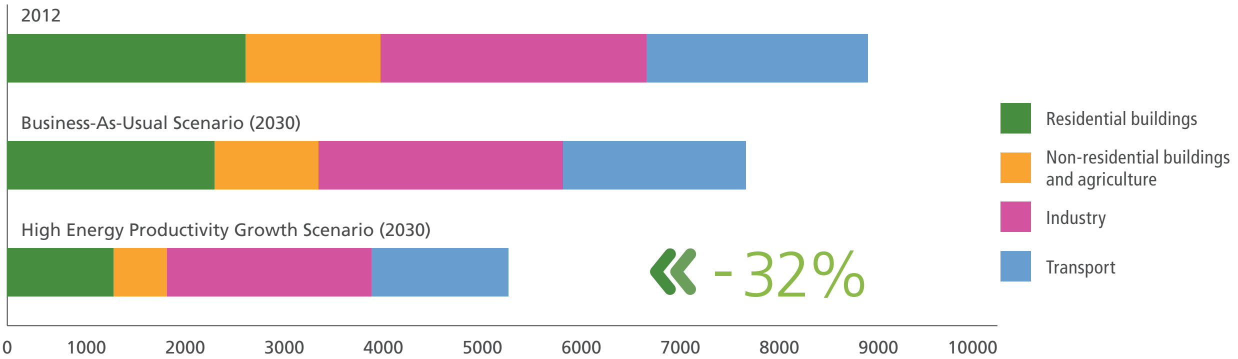
http://pro.et-model.com/scenarios/363850

Link: Business-As-Usual Scenario

http://pro.et-model.com/scenarios/363816

	2012	2030
Population (millions)	80.3	77.9
Household size	2.2	2.10
Number of households (millions)	36	37
GDP (in billions of euros)	2 673	3 109

Final energy consumption in Germany in two scenarios (in petajoules)



Final energy consumption per sector (in petajoules)

Sector	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)	Business-As-Usual Scenario / Annual Growth in 2030	High Energy Productivity Growth Scenario /Annual Growth in 2030
Residential	2 403.8	2 090.8	1 071.7	-0.8%	-4.4%
Non-residential and agriculture	1 363.9	1 051.4	541.9	-1.4%	-5.0%
Industry	2 685.3	2 469.5	2 060.4	-0.5%	-1.5%
Transport	2 238.1	1 847.6	1 384.6	-1.1%	-2.6%
Total excluding non energy use	8 713.5	7 481.7	5 081.0	-0.8%	-3.0%
Non-energy use	*900.7*	*884.6*	*884.6*	*-0.1%*	*-0.1%*

Primary energy consumption per carrier (in petajoules)

Energy carrier	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)	Business-As-Usual Scenario / Annual Growth in 2030	High Energy Productivity Growth Scenario / Annual Growth in 2030
Bio-fuels	1100.6	1437.1	1023.3	1.5%	-0.4%
Oil	4 304.1	3 296.3	2 483.4	-1.5%	-3.0%
Gas	3 040.1	3 180.2	1 956.4	0.3%	-2.4%
Coal	3 030.1	1 635.7	1 348.0	-3.4%	-4.4%
Renewable electricity	343.3	873.7	825.5	5.3%	5.0%
Uranium	1 077.4	-	-	-100.0%	-100.0%
Total	**12 895.5**	**1 0436.0**	**7 636.6**	**-1.2%**	**-2.9%**

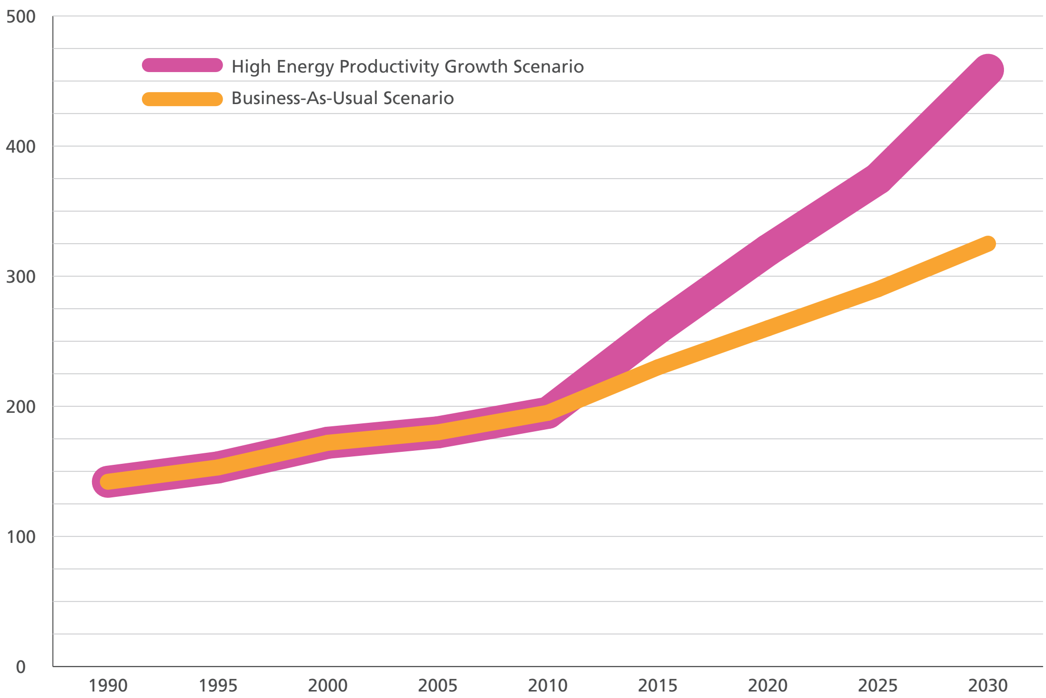
Final energy consumption per carrier, including non-energy use (in petajoules)

Energy carrier	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)	Business-As-Usual Scenario / Annual Growth in 2030	High Energy Productivity Growth Scenario / Annual Growth in 2030
Bio-fuels	452.3	501.5	295.4	0.6%	-2.3%
Oil	4 068.2	3 112.3	2 358.4	-1.5%	-3.0%
Gas	2 259.4	1 926.6	1 065.5	-0.9%	-4.1%
Coal	302.3	215.0	142.2	-1.9%	-4.1%
Solar	24.1	23.1	17.5	-0.2%	-1.8%
Electricity	1 946.8	1 963.1	1 614.8	0.0%	-1.0%
Hot water	561.3	624.7	471.8	0.6%	-1.0%

Energy productivity (in billions of euros per exajoule of energy consumed)

	1990	1995	2000	2005	2010	2030	Average Annual Growth (1990-2010)	Average Annual Growth (2010-2030)
Business-As-Usual Scenario	140	163	179	185	201	325	1.8%	2.4%
High Energy Productivity Growth Scenario	140	163	179	185	201	460	1.8%	4.2%

The impact of energy productivity on GDP (in billions of euros per exajoule)



Energy consumption per household (in gigajoules)

	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)
Residential energy consumption per household	66	56	29

Netherlands

Annual economic growth (2010-2030)

+ 1.34%

Link: High Energy Productivity Growth Scenario

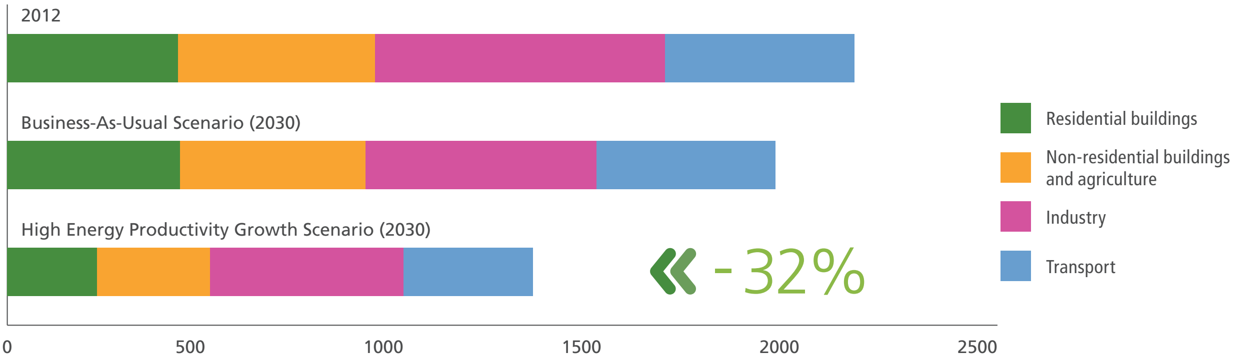
http://pro.et-model.com/scenarios/363845

Link: Business-As-Usual Scenario

http://pro.et-model.com/scenarios/363119

	2012	2030
Population (millions)	16.7	17.6
Household size	2.2	2.10
Number of households (millions)	7	8
GDP (in billions of euros)	563	737

Final energy consumption in the Netherlands in two scenarios (in petajoules)



Final energy consumption per sector (in petajoules)

Sector	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)	Business-As-Usual Scenario / Annual Growth in 2030	High Energy Productivity Growth Scenario /Annual Growth in 2030
Residential	430.6	436.6	227.0	0.1%	-3.5%
Non-residential and agriculture	497.4	467.4	285.1	-0.3%	-3.0%
Industry	732.5	582.8	488.0	-1.3%	-2.2%
Transport	478.1	453.1	327.0	-0.3%	-2.1%
Total excluding non energy use	2 140.2	1 941.5	1 329.3	-0.5%	-2.6%
Non-energy use	*610.8*	*812.9*	*812.9*	*1.6%*	*1.6%*

Primary energy consumption per carrier (in petajoules)

Energy carrier	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)	Business-As-Usual Scenario / Annual Growth in 2030	High Energy Productivity Growth Scenario / Annual Growth in 2030
Bio-fuels	129.8	194.9	156.6	2.3%	1.0%
Oil	1 267.8	1 311.8	1 136.0	0.2%	-0.6%
Gas	1 393.6	1 208.6	758.2	-0.8%	-3.3%
Coal	306.0	343.2	277.6	0.6%	-0.5%
Renewable electricity	19.2	124.9	120.5	11.0%	10.7%
Uranium	44.0	51.8	45.9	0.9%	0.2%
Total	**3 272.7**	**3 235.1**	**2 494.8**	**-0.1%**	**-1.5%**

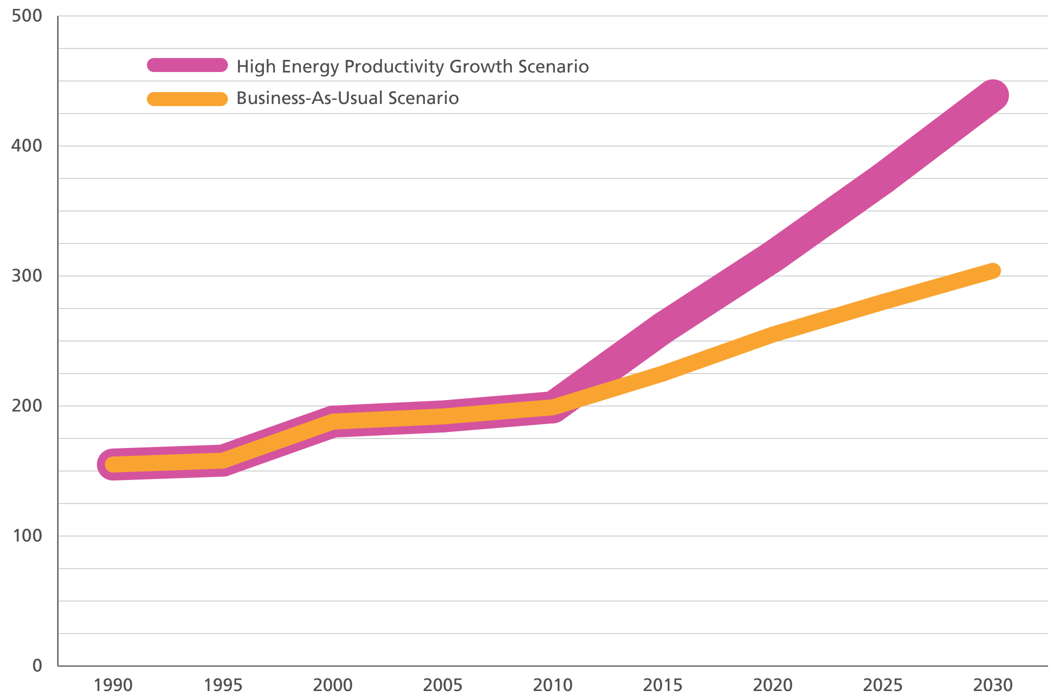
Final energy consumption per carrier, including non-energy use (in petajoules)

Energy carrier	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)	Business-As-Usual Scenario / Annual Growth in 2030	High Energy Productivity Growth Scenario / Annual Growth in 2030
Bio-fuels	31.1	60.9	38.3	3.8%	1.2%
Oil	1 221.7	1 269.2	1 103.8	0.2%	-0.6%
Gas	904.0	814.3	482.7	-0.6%	-3.4%
Coal	36.7	38.1	25.0	0.2%	-2.1%
Solar	1.1	1.1	0.8	0.3%	-1.6%
Geothermal	0.5	0.3	0.4	-3.3%	-1.0%
Electricity	400.4	435.5	362.2	0.5%	-0.6%
Hot water	155.2	134.7	112.9	-0.8%	-1.8%

Energy productivity (in billions of euros per exajoule of energy consumed)

	1990	1995	2000	2005	2010	2030	Average Annual Growth (1990-2010)	Average Annual Growth (2010-2030)
Business-As-Usual Scenario	155	158	188	192	199	304	1.3%	2.1%
High Energy Productivity Growth Scenario	155	158	188	192	199	439	1.3%	4.0%

The impact of energy productivity on GDP (in billions of euros per exajoule)



Energy consumption per household (in gigajoules)

	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)
Residential energy consumption per household	58	52	27

Poland

Annual economic growth (2010-2030)

+2.35%

Link: High Energy Productivity Growth Scenario

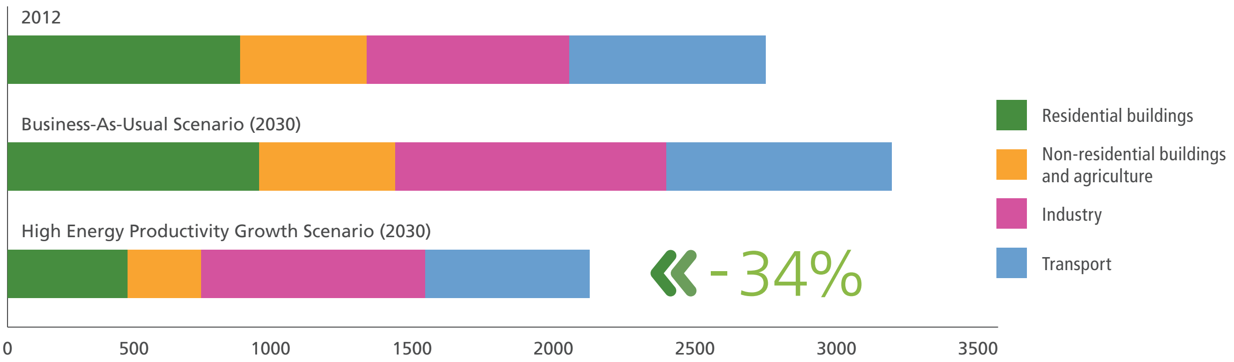
http://pro.et-model.com/scenarios/363852

Link: Business-As-Usual Scenario

http://pro.et-model.com/scenarios/363802

	2012	2030
Population (millions)	38.5	37.6
Household size	2.9	2.60
Number of households (millions)	13	14
GDP (in billions of euros)	676	1 011

Final energy consumption in Poland in two scenarios (in petajoules)



Final energy consumption per sector (in petajoules)

Sector	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)	Business-As-Usual Scenario / Annual Growth in 2030	High Energy Productivity Growth Scenario /Annual Growth in 2030
Residential	820.4	888.0	424.1	0.4%	-3.6%
Non-residential and agriculture	448.9	482.0	259.5	0.4%	-3.0%
Industry	715.4	956.9	791.3	1.6%	0.6%
Transport	693.9	797.2	581.8	0.8%	-1.0%
Total excluding non energy use	2 698.3	3 145.6	2 078.1	0.9%	-1.4%
Non-energy use	*181.9*	*237.7*	*237.7*	*1.5%*	*1.5%*

Primary energy consumption per carrier (in petajoules)

Energy carrier	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)	Business-As-Usual Scenario / Annual Growth in 2030	High Energy Productivity Growth Scenario / Annual Growth in 2030
Bio-fuels	306.7	444.6	269.7	2.1%	-0.7%
Oil	1 018.6	1 110.7	831.2	0.5%	-1.1%
Gas	592.2	926.9	500.1	2.5%	-0.9%
Coal	2 180.4	1 930.0	1 601.8	-0.7%	-1.7%
Renewable electricity	23.8	74.8	71.4	6.6%	6.3%
Green gas	-	0.7	-	-	-
Uranium	-	495.2	472.5	-	-
Total	**4 121.8**	**4 983.0**	**3 746.7**	**1.1%**	**-0.5%**

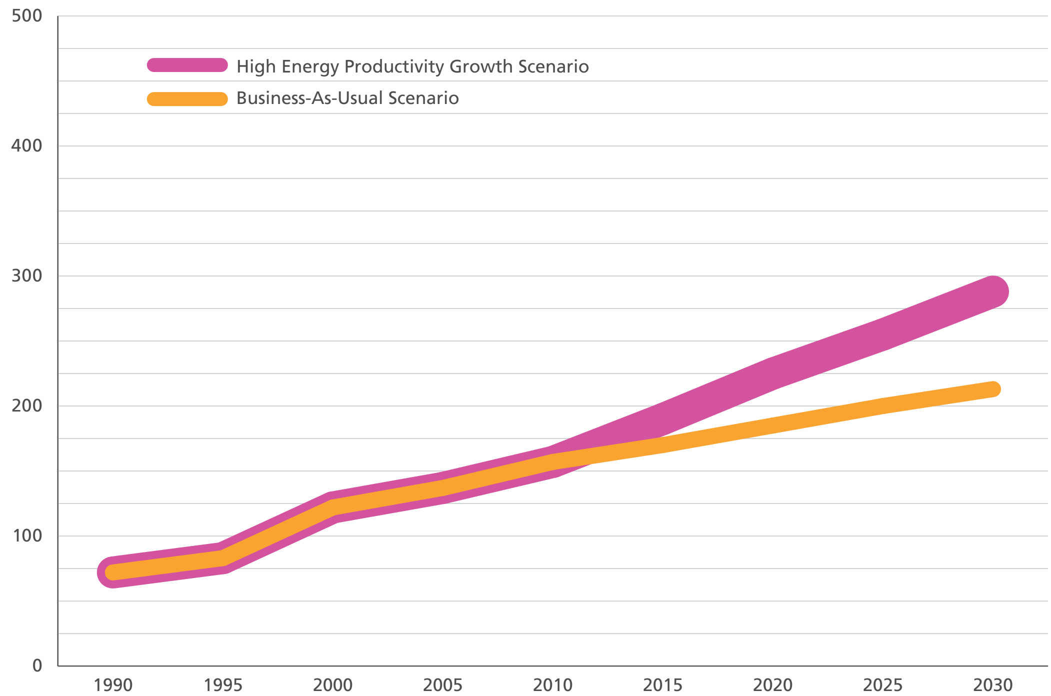
Final energy consumption per carrier, including non-energy use (in petajoules)

Energy carrier	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)	Business-As-Usual Scenario / Annual Growth in 2030	High Energy Productivity Growth Scenario / Annual Growth in 2030
Bio-fuels	218.9	287.2	183.5	1.5%	-1.0%
Oil	949.0	1 036.4	773.9	0.5%	-1.1%
Gas	499.9	727.5	435.6	2.1%	-0.8%
Coal	445.2	345.2	217.5	-1.4%	-3.9%
Solar	0.5	0.6	0.4	0.1%	-1.4%
Electricity	477.8	650.0	509.9	1.7%	0.4%
Hot water	288.6	335.8	179.7	0.8%	-2.6%

Energy productivity (in billions of euros per exajoule of energy consumed)

	1990	1995	2000	2005	2010	2030	Average Annual Growth (1990-2010)	Average Annual Growth (2010-2030)
Business-As-Usual Scenario	72	83	122	137	157	213	4.0%	1.5%
High Energy Productivity Growth Scenario	72	83	122	137	157	288	4.0%	3.1%

The impact of energy productivity on GDP (in billions of euros per exajoule)



Energy consumption per household (in gigajoules)

	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)
Residential energy consumption per household	62	61	29

Spain

Annual economic growth (2010-2030)

+2.07%

Link: High Energy Productivity Growth Scenario

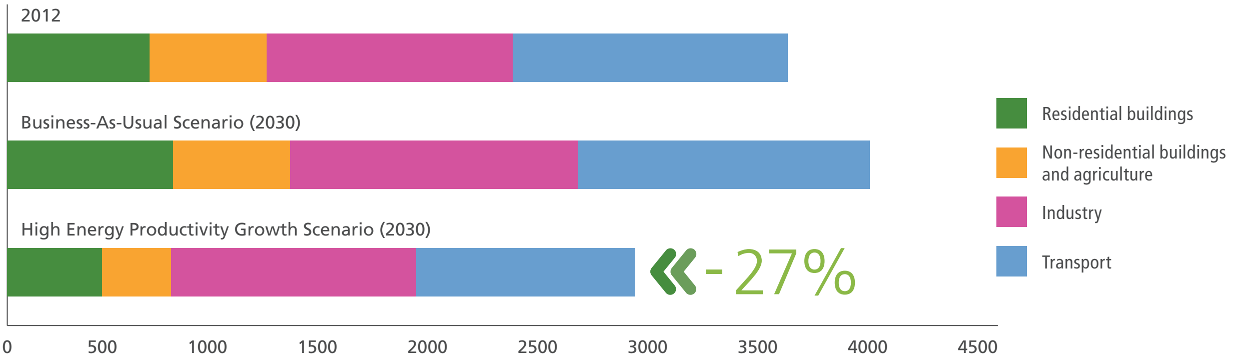
http://pro.et-model.com/scenarios/363842

Link: Business-As-Usual Scenario

http://pro.et-model.com/scenarios/363828

	2012	2030
Population (millions)	46.8	50.0
Household size	2.70	2.50
Number of households (millions)	17	20
GDP (in billions of euros)	1 155	1 768

Final energy consumption in Spain in two scenarios (in petajoules)



Final energy consumption per sector (in petajoules)

Sector	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)	Business-As-Usual Scenario / Annual Growth in 2030	High Energy Productivity Growth Scenario / Annual Growth in 2030
Residential	647.4	753.2	431.1	0.8%	-2.2%
Non-residential and agriculture	530.0	530.9	312.3	0.0%	-2.9%
Industry	1 117.3	1 309.7	1 112.9	0.9%	0.0%
Transport	1 250.2	1 322.7	995.7	0.3%	-1.3%
Total excluding non energy use	3 617.2	3 994.4	2 929.8	0.6%	-1.2%
Non-energy use	*240.9*	*273.1*	*273.1*	*0.7%*	*0.7%*

Primary energy consumption per carrier (in petajoules)

Energy carrier	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)	Business-As-Usual Scenario / Annual Growth in 2030	High Energy Productivity Growth Scenario / Annual Growth in 2030
Bio-fuels	283.0	394.9	249.9	1.9%	-0.7%
Oil	2 199.5	2 096.0	1 607.1	-0.3%	-1.7%
Gas	1 147.2	1 349.6	888.1	0.9%	-1.4%
Coal	645.9	455.8	328.5	-1.9%	-3.7%
Renewable electricity	282.2	564.9	516.9	3.9%	3.4%
Green gas	-	1.4	-	-	-
Uranium	639.2	593.1	440.7	-0.4%	-2.0%
Total	**5 197.0**	**5 455.9**	**4 031.1**	**0.3%**	**-1.4%**

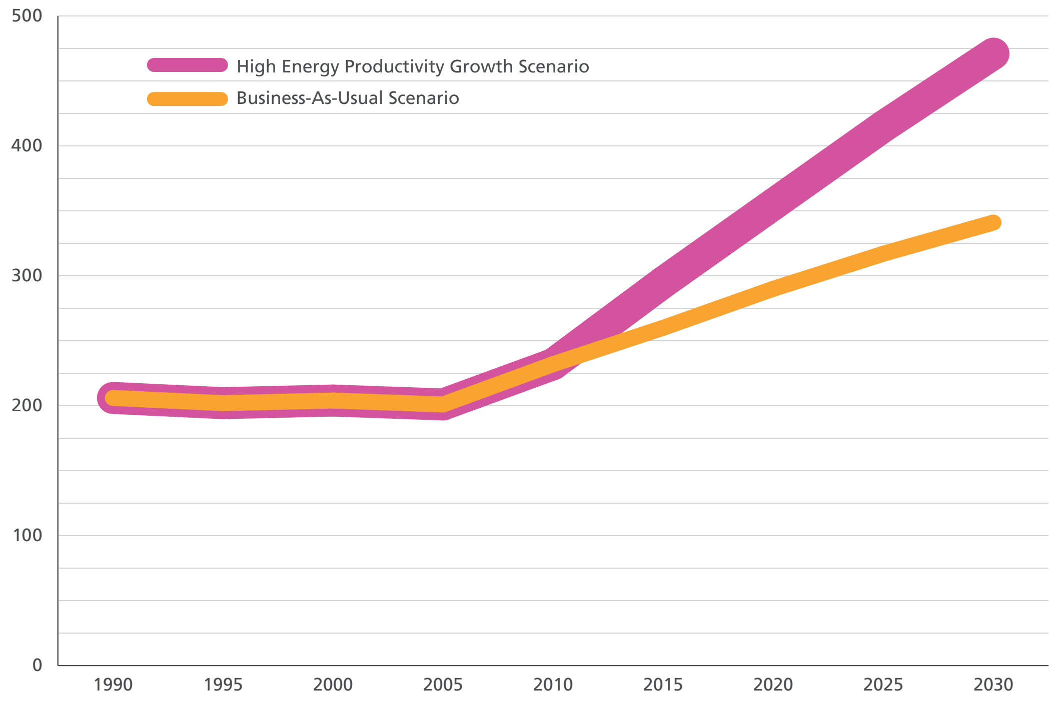
Final energy consumption per carrier, including non-energy use (in petajoules)

Energy carrier	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)	Business-As-Usual Scenario / Annual Growth in 2030	High Energy Productivity Growth Scenario / Annual Growth in 2030
Bio-fuels	241.0	313.1	190.0	1.5%	-1.3%
Oil	1 981.4	1 977.3	1 513.7	0.0%	-1.5%
Gas	580.8	709.3	508.7	1.1%	-0.7%
Coal	35.9	48.4	45.1	1.7%	1.3%
Solar	9.1	10.6	6.8	0.9%	-1.6%
Geothermal	0.2	0.2	0.2	0.0%	0.0%
Electricity	889.0	1 076.9	818.1	1.1%	-0.5%
Hot water	120.4	131.5	105.1	0.5%	-0.8%

Energy productivity (in billions of euros per exajoule of energy consumed)

	1990	1995	2000	2005	2010	2030	Average Annual Growth (1990-2010)	Average Annual Growth (2010-2030)
Business-As-Usual Scenario	206	202	204	201	232	341	0.6%	1.9%
High Energy Productivity Growth Scenario	206	202	204	201	232	471	0.6%	3.6%

The impact of energy productivity on GDP (in billions of euros per exajoule)



Energy consumption per household (in gigajoules)

	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)
Residential energy consumption per household	38	38	22

United Kingdom

Annual economic growth (2010-2030)

+ 1.82%

Link: High Energy Productivity Growth Scenario

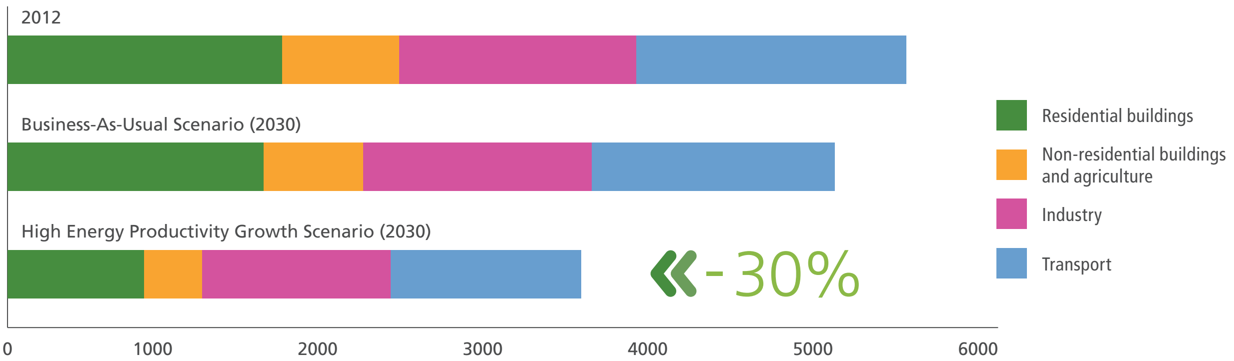
http://pro.et-model.com/scenarios/363847

Link: Business-As-Usual Scenario

http://pro.et-model.com/scenarios/363789

	2012	2030
Population (millions)	63.5	70.2
Household size	2.2	2.20
Number of households (millions)	28	32
GDP (in billions of euros)	1 748	2 471

Final energy consumption in the United Kingdom in two scenarios (in petajoules)



Final energy consumption per sector (in petajoules)

Sector	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)	Business-As-Usual Scenario / Annual Growth in 2030	High Energy Productivity Growth Scenario / Annual Growth in 2030
Residential	1 661.3	1 550.8	824.5	-0.4%	-3.8%
Non-residential and agriculture	709.1	600.9	353.2	-0.9%	-3.8%
Industry	1 437.5	1 384.9	1 143.1	-0.2%	-1.3%
Transport	1 634.1	1 473.1	1 151.8	-0.6%	-1.9%
Total excluding non energy use	5 492.9	5 061.1	3 524.3	-0.5%	-2.4%
Non-energy use	*274.3*	*311.0*	*311.0*	*0.7%*	*0.7%*

Primary energy consumption per carrier (in petajoules)

Energy carrier	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)	Business-As-Usual Scenario / Annual Growth in 2030	High Energy Productivity Growth Scenario / Annual Growth in 2030
Bio-fuels	245.9	373.9	274.8	2.4%	0.6%
Oil	2 521.5	2 099.9	1 640.9	-1.0%	-2.4%
Gas	2 790.7	2 940.7	1 711.0	0.3%	-2.7%
Coal	1 533.7	240.4	198.0	-9.8%	-10.8%
Renewable electricity	93.8	574.5	539.5	10.6%	10.2%
Green gas	-	2.5	-	-	-
Uranium	792.1	494.8	382.6	-2.6%	-4.0%
Total	**8 057.0**	**6 726.7**	**4 746.8**	**-1.0%**	**-2.9%**

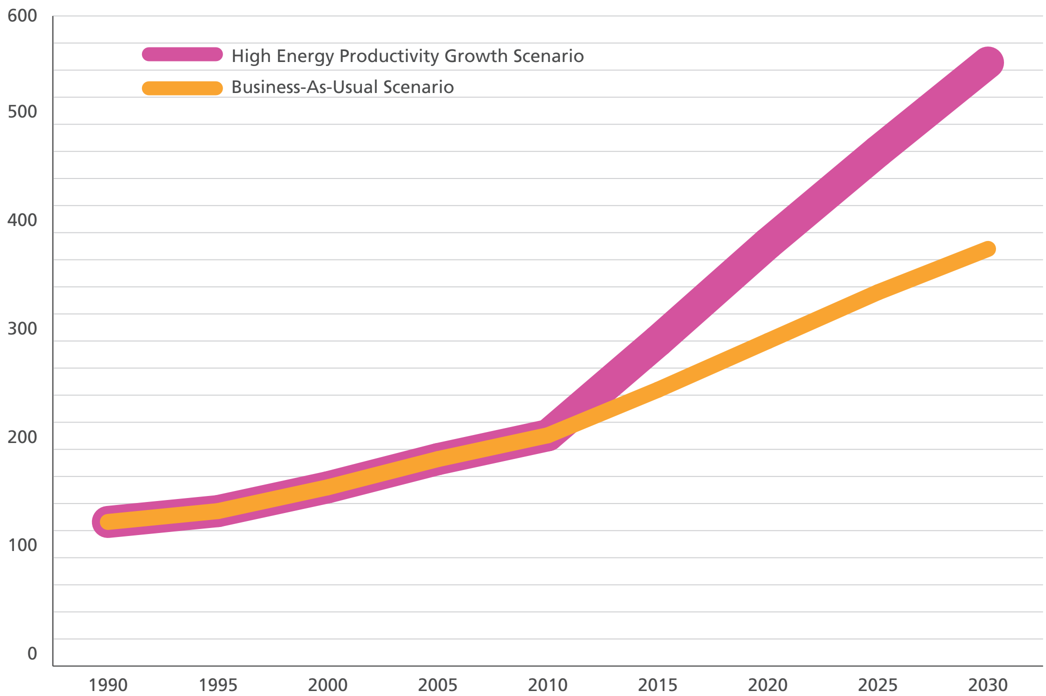
Final energy consumption per carrier, including non-energy use (in petajoules)

Energy carrier	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)	Business-As-Usual Scenario / Annual Growth in 2030	High Energy Productivity Growth Scenario / Annual Growth in 2030
Bio-fuels	74.9	195.8	137.2	5.5%	3.4%
Oil	2 363.0	1 958.9	1 545.3	-1.0%	-2.3%
Gas	1 923.1	1 828.1	1 100.8	-0.3%	-3.1%
Coal	96.3	78.3	58.3	-1.1%	-2.8%
Electricity	1 175.0	1 193.1	887.3	0.1%	-1.5%
Hot water	134.9	117.3	103.5	-0.8%	-1.5%

Energy productivity (in billions of euros per exajoule of energy consumed)

	1990	1995	2000	2005	2010	2030	Average Annual Growth (1990-2010)	Average Annual Growth (2010-2030)
Business-As-Usual Scenario	133	143	165	191	213	385	2.4%	3.0%
High Energy Productivity Growth Scenario	133	143	165	191	213	557	2.4%	4.9%

The impact of energy productivity on GDP (in billions of euros per exajoule)



Energy consumption per household (in gigajoules)

	2012	Business-As-Usual Scenario (2030)	High Energy Productivity Growth Scenario (2030)
Residential energy consumption per household	60	49	26

‘Germany could decrease its annual final energy consumption by as much as 32% by 2030 through more aggressive use of existing technology.’

Where will the jobs come from?

How are jobs created through energy efficiency? For the most part, jobs are created from additional investment in energy-efficient equipment and services. The Copenhagen Climate Council estimated that an investment in a coal-fired power plant creates about 30,000 jobs per exajoule of electricity generated, but the equivalent spending on energy-efficient devices would create more than 100,000 jobs per exajoule of saved electricity [see Ditlev Engel and Daniel M. Kammen, *Green Jobs and the Clean Energy Economy* (Copenhagen: Copenhagen Climate Council, 2009)].

To be sure, measures to save energy can result in the loss of some jobs in energy inefficient sectors, but the reduced fuel bill can also mean that additional money is available to be spent in other sectors – such as public health – which are often more labour-intensive than the energy sector. This results in greater welfare for society at large and a net creation of jobs. With that scenario in mind, the American Council for an Energy Efficient Economy (ACEEE) calculated that 60,000 jobs would be created in the US for every exajoule of energy saved [American Council for an Energy Efficient Economy, *Appliance and Equipment Efficiency Standards: A Moneymaker and Job Creator* (Washington, DC: ACEEE, 2011)]. Later, Ecofys used the ACEEE methodology to analyse the European situation, where, for example, a different labour intensity is found in the electricity sector. Ecofys found that efforts to reduce the overall energy bill in Europe by around €120 billion would create as many as one million new jobs net of any losses in the old sectors [See Edith Molenbroek, Maarten Cuijpers and Kornelis Blok, *Economic Benefits of the EU Ecodesign Directive: Improving European Economies* (Utrecht: Ecofys, 2012)]. By applying the same approach to the World, Ecofys found that tapping the global energy efficiency could yield more than six million jobs by 2020. [See Kornelis Blok and Pieter van Breevoort, “The Benefits of Energy Efficiency – Why Wait?” (Utrecht: Ecofys, 2012)].

If we apply the same the methodology to the High Energy Productivity Scenario developed in this paper – with 15 exajoule of energy savings and a reduction of the fuel bill by more than €200 billion – the net job impact would range between 900,000 and 1.8 million jobs. The numbers are in line with estimates from the European Commission, which calculated that the net impact of its 2020 energy efficiency target would be 400,000 jobs. The Energy Transition Model – developed by Quintel Intelligence and used throughout this study – estimated about 50,000 additional jobs would be created in the Netherlands for every 613 petajoules of energy saved from the Business-As-Usual Scenario. If we translate that figure to Europe as a whole – with 15 exajoules of savings – it would imply 1.2 million additional jobs. See Quintel, *Energy Transition Model* at www.energytransitionmodel.com.

'The Netherlands could trim its overall final energy use to 1.3 exajoules by 2030, down from 2.1 exajoules in 2012 – a 38% improvement.'

Appendix I. Global Energy Productivity Index

GDP per unit of energy consumed, in billions of euros per exajoule

Rank	Country	2011
1	Hong Kong SAR, China	456,21
2	Cuba	364,81
3	Colombia	330,36
4	Singapore	328,57
5	Switzerland	309,54
6	Sri Lanka	309,42
7	Peru	287,45
8	Ireland	287,28
9	Panama	283,34
10	Dominican Republic	283,24
11	Congo, Rep.	273,22
12	Gabon	265,66
13	Malta	261,87
14	Uruguay	258,24
15	Philippines	255,59
16	Albania	254,70
17	Denmark	248,91
18	Morocco	246,84
19	Costa Rica	246,53
20	Italy	245,78
21	Portugal	241,53
22	Botswana	239,06
23	Spain	236,15
24	Turkey	234,04
25	Namibia	232,30
26	United Kingdom	230,92
27	Yemen, Rep.	229,01
28	Azerbaijan	228,86
29	Bangladesh	227,97
30	Algeria	225,43
31	Egypt, Arab Rep.	224,35
32	Norway	224,29
33	Tunisia	222,32
34	Greece	220,20
35	Germany	220,18
36	Ecuador	219,32
37	Cyprus	218,28
38	Austria	216,52
39	Lebanon	216,43
40	Netherlands	214,62
41	Lithuania	211,74
42	Luxembourg	210,26
43	Brazil	210,01
44	Croatia	209,38
45	Iraq	207,39
	European Union	**206,22**
46	Israel	204,11
47	El Salvador	202,53
48	Angola	201,34
49	Mexico	201,31
50	Chile	200,80
51	Japan	195,72
52	Indonesia	195,29
53	Romania	191,55
54	Guatemala	191,06
55	Jordan	190,01
56	France	186,35
57	Paraguay	185,19
58	Hungary	184,42
59	Latvia	181,84
60	Saudi Arabia	181,32
61	Pakistan	174,20
62	Malaysia	171,67
	OECD members	**170,98**
63	Sudan	169,44
64	Eritrea	167,53
65	Kuwait	166,58
66	Georgia	165,27
67	Poland	164,71
68	Qatar	163,88
69	Thailand	162,81
70	Belgium	161,84
71	Slovak Republic	159,32
72	India	159,01
73	Sweden	158,42
74	Senegal	158,41

‘The Polish economy is set to continue growing with a near doubling of GDP between 2010 and 2030.’

Rank	Country	2011
75	Nicaragua	156,55
76	Ghana	154,24
77	Slovenia	153,39
78	New Zealand	152,18
79	Cameroon	149,52
80	Australia	149,52
81	Macedonia, FYR	149,16
82	United Arab Emirates	148,07
83	Montenegro	145,86
84	Brunei Darussalam	145,31
85	Jamaica	143,28
86	Armenia	142,73
87	United States	142,70
	World Average	**142,63**
88	Bolivia	139,13
89	Nigeria	137,60
90	Cambodia	137,56
91	Venezuela, RB	136,64
92	Tajikistan	136,56
93	Vietnam	135,14
94	Honduras	134,84
95	Korea, Rep.	133,87
96	Czech Republic	131,29
97	Canada	118,16
98	Finland	117,88
99	Belarus	116,75
100	Iran, Islamic Rep.	116,75
101	Bulgaria	115,28
102	Oman	114,67
103	Kosovo	111,51
104	Mongolia	108,38
105	Serbia	105,66
106	Libya	105,47
107	Estonia	105,27
108	Bahrain	103,65
109	Nepal	101,03
110	Kyrgyz Republic	100,80
111	China	97,62
112	Bosnia and Herzegovina	97,14
113	Haiti	93,50
114	Russian Federation	91,87

Rank	Country	2011
115	Zambia	88,19
116	South Africa	85,18
117	Kazakhstan	84,84
118	Kenya	84,26
119	Cote d'Ivoire	83,86
120	Benin	80,88
121	Trinidad and Tobago	66,97
122	Tanzania	65,54
123	Ukraine	59,55
124	Ethiopia	57,21
125	Togo	56,53
126	Uzbekistan	53,51
127	Turkmenistan	44,41
128	Zimbabwe	44,18
129	Iceland	42,84
130	Mozambique	42,18
131	Congo, Dem. Rep.	32,48

Source: Worldbank, IEA, Ecofys analysis
Not all countries could be assessed on the basis of available data.

‘The Spanish economy is suffering from a prolonged period of chronic underinvestment in key technologies, including energy-saving technologies.’

APPENDIX II. Improvement in Global Energy Productivity Index (2001-2011)

Rank	Country	2011
1	Azerbaijan	12,81%
2	Uzbekistan	8,09%
3	Tajikistan	6,60%
4	Lithuania	6,60%
5	Cuba	6,50%
6	Nigeria	6,45%
7	Ethiopia	6,10%
8	Belarus	5,74%
9	Slovak Republic	5,47%
10	Dominican Republic	5,44%
11	Angola	5,22%
12	Ukraine	4,87%
13	Romania	4,31%
14	Singapore	4,29%
15	Armenia	4,28%
16	Philippines	4,24%
17	Mozambique	4,14%
18	Ghana	4,03%
19	Hong Kong SAR, China	4,01%
20	Mongolia	3,65%
21	Lebanon	3,58%
22	Georgia	3,56%
23	Turkmenistan	3,54%
24	Sudan	3,53%
25	Bulgaria	3,52%
26	Russian Federation	3,47%
27	Sri Lanka	3,40%
28	United Kingdom	3,28%
29	Cambodia	3,27%
30	Panama	3,18%
31	Poland	3,06%
32	Jamaica	3,04%
33	Tanzania	3,02%
34	Czech Republic	3,00%
35	Zambia	2,95%
36	Latvia	2,83%
37	Ireland	2,82%
38	Cameroon	2,76%
39	Serbia	2,76%
40	Botswana	2,72%
41	India	2,63%
42	Albania	2,62%
43	Sweden	2,59%
44	Indonesia	2,54%
45	Qatar	2,49%
46	Hungary	2,31%
47	Germany	2,27%
48	Switzerland	2,26%
49	Estonia	2,18%
50	Colombia	2,08%
51	Canada	2,04%
52	Congo, Dem. Rep.	1,95%
53	Jordan	1,93%
	European Union	**1,89%**
54	Tunisia	1,84%
55	United States	1,82%
56	Paraguay	1,82%
57	Japan	1,76%
58	China	1,75%
59	Israel	1,69%
	OECD average	**1,66%**
60	Kosovo	1,57%
61	Namibia	1,57%
62	Nepal	1,55%
63	Slovenia	1,54%
64	Belgium	1,53%
65	Australia	1,52%
66	El Salvador	1,52%
67	Pakistan	1,51%
68	Netherlands	1,47%
69	Malaysia	1,46%
70	Croatia	1,45%
71	Nicaragua	1,44%
72	Greece	1,43%
73	Finland	1,43%
74	Spain	1,39%

‘The United Kingdom boasts one of Europe’s largest and most developed service sectors, which as a rule carries a lighter energy footprint than more industry-dependent economies.’

Rank	Country	2011
75	Korea, Rep.	1,38%
76	New Zealand	1,38%
77	Macedonia, FYR	1,37%
	World average	**1,32%**
78	France	1,31%
79	Denmark	1,31%
80	Cyprus	1,21%
81	South Africa	1,14%
82	Malta	1,06%
83	Bangladesh	1,03%
84	Venezuela, RB	1,00%
85	Portugal	0,96%
86	Saudi Arabia	0,94%
87	Senegal	0,87%
88	Norway	0,80%
89	Iran, Islamic Rep.	0,74%
90	Kenya	0,73%
91	Bahrain	0,73%
92	Luxembourg	0,71%
93	Kuwait	0,70%
94	Austria	0,69%
95	Turkey	0,60%
96	Kyrgyz Republic	0,57%
97	Italy	0,50%
98	Peru	0,49%
99	Eritrea	0,48%
100	Honduras	0,30%
101	Thailand	0,27%
102	Chile	0,15%
103	Brazil	0,14%
104	Togo	0,03%
105	Gabon	0,03%
106	Morocco	-0,01%
107	Guatemala	-0,03%
108	Vietnam	-0,05%
109	Iraq	-0,25%
110	Costa Rica	-0,25%
111	Ecuador	-0,35%
112	Egypt, Arab Rep.	-0,38%
113	Mexico	-0,39%
114	Kazakhstan	-0,82%

Rank	Country	2011
115	Algeria	-0,90%
116	Trinidad and Tobago	-1,03%
117	Uruguay	-1,08%
118	Bosnia and Herzegovina	-1,40%
119	Yemen, Rep.	-1,48%
120	United Arab Emirates	-1,56%
121	Congo, Rep.	-1,78%
122	Benin	-2,23%
123	Zimbabwe	-3,41%
124	Iceland	-3,42%
125	Haiti	-3,70%
126	Libya	-3,91%
127	Brunei Darussalam	-4,02%
128	Cote d'Ivoire	-4,86%
129	Oman	-5,52%
130	Bolivia	-5,52%

Source: Worldbank, IEA, Ecofys analysis
Not all countries could be assessed on the basis of available data.

References and Additional Reading

American Council for an Energy-Efficient Economy. *Appliance and Equipment Efficiency Standards: A Moneymaker and Job Creator* (Washington: ACEEE, 2011)

Appliance Standards Awareness Project. *Development of Fridges in the US between 1972–2014* (Boston: ASAP, 2014)

Van Ark, Bart. *Productivity and Digitalisation in Europe: Paving the Road to Faster Growth* (Brussels & New York: The Lisbon Council & The Conference Board, 2014)

Bermudez, Mara. "The History of the Light Bulb," *Del Mar Fans and Lighting*, 10 January 2014 http://www.delmarfans.com/educate/basics/who-invented-light-bulbs/

Blok, Kornelis, and Pieter van Breevoort. *The Benefits of Energy Efficiency – Why Wait?* (Utrecht: Ecofys, 2012)

Bressand, Florian, Diana Farrell, Pedro Haas, Fabrice Morin, Scott Nyquist, Jaana Remes, Sebastian Roemer, Matt Rogers, Jaeson Rosenfeld and Jonathan Woetzel. *Curbing Global Energy-Demand Growth: The Energy Productivity Opportunity* (San Francisco: McKinsey Global Institute, 2007)

Brown, Nicholas. "Most Efficient White LED Lamp Developed By Philips," *CleanTechnica*, 18 April 2013 http://cleantechnica.com/2013/04/18/most-efficient-white-led-lamp-developed-by-philips/

Craven, Paddy. *LED Technology: Developments and Applications*, presentation at Chartered Institution of Building Services Engineers (CIBSE) Conference, Dublin, 06 March 2012 http://www.cibseireland.org/wp-content/uploads/2012/03/CIBSELED06032012-Compatibility-Mode.pdf

Department of Energy and Climate Change. *Energy Efficient Products: Helping us Cut Energy Use* (London: UK Department of Energy and Climate Change, 2014)

DieselNet. "Emission Standards, United States, Cars: Fuel Economy (1978-2011)," *DieselNet*, August 2013 http://www.dieselnet.com/standards/us/fe.php

DiLaura, David. "A Brief History of Lighting" in *Optics and Photonics News* Vol. 19, Issue 9, pp. 22–28, 2008 http://www.osa-opn.org/home/articles/volume_19/issue_9/features/a_brief_history_of_lighting/

Engel, Ditliv, and Daniel M. Kammen. *Green Jobs and the Clean Energy Economy* (Copenhagen: Copenhagen Climate Council, 2009)

Ellis, Mark, Nigel Jollands, Lloyd Harrington and Alan Meier. *Do Energy Efficient Appliances Cost More?*, in Sophie Attali and Kenya Tillerson, *European Council for an Energy Efficient Economy 2007 Summer Study, Saving Energy – Just Do It! Conference proceedings*

European Commission. *EU Energy, Transport and GHG Emissions. Trends to 2050. Reference Scenario 2013* (Brussels: European Commission, 2013)

Farrell, Diana, Jaana Remes, Florian Bressand, Mark Laabs and Anjan Sundaram. *The Case for Investing in Energy Productivity* (San Francisco: McKinsey Global Institute, 2008)

Giddens, Anthony. *The Politics of Climate Change* (London: Wiley, 2013)
--------------. *Turbulent and Mighty Continent: What Future for Europe* (Cambridge: Polity, 2014)

Hammer, Ed. “CFL ‘On-Time’ and Safety,” *Drop the Hammer*, 02 June 2008

Hermelink, Andreas H., and Astrid Müller. *Economics of Deep Renovation. Implications of a Set of Case Studies* (Berlin: ECOFYS Germany, 2011)

International Energy Agency. *Capturing the Multiple Benefits of Energy Efficiency: A Guide to Quantifying the Value Added* (Paris: OECD, 2014)
———. *Energy Balances of Non-OECD Countries* (Paris: OECD, 2013)
———. *Energy Balances of OECD Countries* (Paris: OECD, 2013)
———. *World Energy Outlook 2012* (Paris: OECD, 2012)
———. *World Energy Outlook 2013* (Paris: OECD, 2012)

Institut Wohnen und Umwelt. *Deutsche Gebäudetypologie. Systematik und Datensätze* (Darmstadt: IWU, 2011)

Kodjak, Drew, Anup Bandivadekar, John German and Nicholas Lutsey. *The Regulatory Engine: How Smart Policy Drives Vehicle Innovation* (Washington: International Council on Clean Transportation, 2011)

Laitner, John A., and Mike Berners-Lee. *GeSI SMARTer 2020: The Role of ICT in Driving a Sustainable Future* (Global e-Sustainability Initiative and The Boston Consulting Group, 2012)

Kojima, Kazunori, and Lisa Ryan. *Transport Energy Efficiency. Implementation of IEA Recommendations Since 2009 and Next Steps* (Paris: OECD, 2010)

Loy, Deltlef. “Impact Assessment for Replacing Refrigerators/ Freezers in SLU,” presentation for The Eastern Caribbean Energy Labelling Project (ECELP), 2013 http://www.oecs.org/ecelp/downloads/doc_download/44-slbs-refrigerator-presentation-loy-3-2013

Mock, Peter. *EU CO2 Emission Standards for Passenger Cars and Light-Commercial Vehicles* (Washington: International Council on Clean Transportation, 2014)

Molenbroek, Edith, Maarten Cuijpers and Kornelis Blok. *Economic Benefits of the EU Ecodesign Directive: Improving European Economies* (Utrecht: Ecofys, 2012)

Nadel, Steven. “Today is the 40th Anniversary of the 1973 Oil Crisis and the Midpoint on the Path to a Truly Energy-Efficient Economy,”*ACEEE Blog*, 17 October 2013 http://www.aceee.org/blog/2013/10/today-40th-anniversary-1973-oil-crisi

Sachs, Jeffrey D., *The End of Poverty: How We Can Make It Happen in Our Lifetime* (London: Penguin, 2005)

Schettler-Köhler, Horst. “Lessons Learned – Member States’ Perspectives; EPBD Implementation in Germany,” Presentation at EUSEW Conference, 31 January 2008 http://www.buildup.eu/system/files/Part2res1_Lessons%20learned_Horst%20Schettler-Kohler_p.pdf

Tsao, Jeffrey Y., and Paul Waide. "The World's Appetite for Light: Empirical Data and Trends Spanning Three Centuries and Six Continents" in *Leukos*, Vol. 6, Issue 4, pp. 259–281, 2010

United Nations, The Secretary-General's High-level Group on Sustainable Energy for All. *Sustainable Energy for All – A Framework for Action* (New York: United Nations, 2012)

United States Environmental Protection Agency. *Energy Independence and Security Act of 2007 (EISA). Frequently Asked Questions* (Washington: EPA, 2011) http://www.energystar.gov/ia/products/lighting/cfls/downloads/EISA_Backgrounder_FINAL_4-11_EPA.pdf

Legislation

European Council, *European Council (23 and 24 October 2014) Conclusions* (Brussels: European Council, 2014).

European Union. Regulation (EC) No 443/2009 of the European Parliament and of the Council of 23 April 2009 setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO2 emissions from light-duty vehicles

United States. Energy Policy and Conservation Act. Public Law 94-163. 22 December 1975, 94th Congress of the United States of America

Databases, Datasets and Technical Specifications

Automobile Catalogue: http://www.automobile-catalog.com

BMW, *BMW i3 Technical Data:* http://www.bmw.com/com/en/newvehicles/i/i3/2013/showroom/technical_data.html

EnergieWeter, *Fridge:* http://aom.energieweter.nl/CategoryPage.aspx?Cat=Fridge

Energy-Economy-Environment Modelling Laboratory E3MLab http://www.e3mlab.ntua.gr/e3mlab/index.php

Eurostat, *Population on 1 January (tps00001)* and *Newsrelease: Euroindicators* 146/2014 30 September 2014: http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home

ODYSSEE Database: http://www.indicators.odyssee-mure.eu/energy-efficiency-database.html

Staffell, Iain, *The Energy and Fuel Data Sheet, 2011* http://www.wogone.com/science/the_energy_and_fuel_data_sheet.pdf

United States Department of Energy, *Compare Cars Side-by-Side* http://www.fueleconomy.gov/feg/Find.do?action=sbs&id=25987&id=33900&id=34699

United States Department of Energy, *Infographic: The Road to Fuel Efficiency*, http://energy.gov/articles/infographic-road-fuel-efficiency

World Bank, *International Comparison Program Database, GDP in PPP* http://data.worldbank.org/indicator/NY.GDP.MKTP.PP.KD

Acknowledgements

The authors and project team would like to thank Anthony Giddens, former director of the London School of Economics and life fellow, King's College Cambridge, and Diane Willkens, president and CEO of Development Finance International, Inc., for their comments on an early draft of this paper. Special thanks as well to Christophe Barton, Isobel Head, Annick Hilbert, Stéphanie Lepczynski and Chrysoula Mitta. As always, any error of fact or judgment remaining are the authors' sole responsibility.

Lisbon Council Policy Brief Vol. 9, No. 1 (2015)
ISSN: 2031-0943 (print) 2031-0951 (online)

First published in Belgium by the Lisbon Council
Responsible editor: Paul Hofheinz

About Ecofys

Established in 1984 with the mission of achieving "sustainable energy for everyone," Ecofys has become the leading expert in renewable energy, energy and carbon efficiency, energy systems and markets as well as energy and climate policies. With a staff of 250, the company is based in Utrecht, Netherlands with offices in Beijing, Berlin, Brussels, Cologne, London and Portland (United States). Its website is www.ecofys.com.

About the Lisbon Council

The Lisbon Council for Economic Competitiveness and Social Renewal is a Brussels-based think tank and policy network. Established in Belgium in 2003 as a non-profit, non-partisan association, the group is dedicated to making a positive contribution through cutting-edge research and by engaging politicians and the public at large in a constructive exchange about Europe's economic and social future.
Its website is www.lisboncouncil.net.

About Quintel Intelligence

Quintel Intelligence is an Amsterdam-based energy modelling and research firm that assists governments, companies and institutions around the world in determining and quantifying their long-term energy strategies. Quintel believes that a better understanding of energy systems and connected food and water systems will help society deal with current and future challenges. Its website is www.quintel.com.

ECOFYS

Ecofys Group
Kanaalweg 15-G
3526 KL Utrecht
The Netherlands

the Lisbon council
think tank for the 21st century

The Lisbon Council asbl
IPC-Résidence Palace
155 rue de la Loi
1040 Brussels, Belgium

QUINTEL INTELLIGENCE

Quintel Intelligence B.V.
Keizersgracht 639
1017 DT Amsterdam
The Netherlands

Design by karakas PRINT