The 2016 International Energy Efficiency Scorecard

Chetana Kallakuri, Shruti Vaidyanathan, Meegan Kelly, Rachel Cluett

July 2016

Report E1602

529 14th Street NW, Suite 600, Washington, DC 20045
Phone: (202) 507-4000 • Twitter: @ACEEEDC
Facebook.com/myACEEE • aceee.org

Contents

About the Authors

Chetana Kallakuri works in the ACEEE National Policy Program on federal energy efficiency policies in the United States. Chetana holds a bachelor of technology degree in electrical engineering from Jawaharlal Nehru Technological University (JNTU) Kakinada in India, and a master of environmental management degree with a concentration in energy from the Yale School of Forestry and Environmental Studies. While in India she worked with the Cerana Foundation, a Hyderabad-based environmental nonprofit. She joined ACEEE in 2015.

Shruti Vaidyanathan is a senior researcher with the Transportation Program at ACEEE. She is the principal analyst for ACEEE's Greenercars.org, a comprehensive environmental ranking of consumer vehicles. Her recent work has also focused on transportation-system efficiency at the state and local levels, particularly the role of information and communications technology in smart transportation systems. Shruti holds a master of science in public policy and management from the Heinz College at Carnegie Mellon University and a bachelor of arts in economics and environmental studies from Grinnell College. She joined ACEEE in 2007.

Meegan Kelly conducts research, analysis, and outreach on the impacts of energy efficiency programs and policies on energy use in the industrial sector. She is also engaged in research on combined heat and power (CHP) and the role of energy efficiency in reducing air pollution. She joined ACEEE in 2014. Meegan holds a master of science degree in energy policy and climate from Johns Hopkins University and a bachelor of science in communications with majors in journalism and philosophy from the University of Miami.

Rachel Cluett's work focuses on residential-sector energy efficiency including energy-use disclosure, product standards, labeling, and efficiency-program design. Rachel has been certified by the Building Performance Institute (BPI) as a building analyst and envelope professional, and she is also a certified Home Energy Rating System (HERS) rater. She came to ACEEE in November 2012 after two years of work conducting residential energy assessments. She earned a bachelor of science in natural resources from Cornell University.

Acknowledgments

This report was made possible through the generous support of a foundation wishing to remain anonymous, the ClimateWorks Foundation, and internal ACEEE funding. The authors gratefully acknowledge the external reviewers, technical experts, internal reviewers, colleagues, and sponsors who supported this report. External review and support do not imply affiliation or endorsement. External expert reviewers included:

John Appleby, Office of Energy Efficiency, Natural Resources Canada
Igor Bashmakov, Center for Energy Efficiency (CENEf), Russia
Daron Bedrosyan, World Bank
Uwe Bigalke, German Energy Agency
Bob Blain, Natural Resources Canada
Odón de Buen, Comisión Nacional para el Uso Eficiente de la Energía, Mexico
Dario Di Santo, Federazione Italiana per l'uso Razionale dell'Energia, Italy
Chris Dunstan, Institute for Sustainable Futures, Australia
Henning Ellermann, Germany Trade & Invest
Meredydd Evans, Pacific Northwest National Laboratory
Nick Eyre, Environmental Change Institute, University of Oxford, United Kingdom
Araceli Fernandez Pales, International Energy Agency
Howard Geller, Southwest Energy Efficiency Project
Bing He, Office of Energy Efficiency, Natural Resources Canada
Bruce Hedman, Institute for Industrial Productivity
Adam Hinge, Sustainable Energy Partnerships
Sho Hirayama, Jyukankyo Research Institute, Japan
Jimmy Kumana, Kumana & Associates
Benoît Lebot, International Partnership for Energy Efficiency Cooperation
Karla Kwiatkowski Lepetitgaland, Electrobras, Brazil
Mark Levine, Lawrence Berkeley National Laboratory
Chiamiao Liu, Industrial Technology Research Institute, Taiwan
Sangeeta Mathew, Alliance for an Energy Efficient Economy
Aimee McKane, Lawrence Berkeley National Laboratory
Conrado Augustus de Melo, University of Campinas, Brazil
Rob Murray-Leach, Energy Efficiency Council, Australia
Padu Padmanaban, Strategic Energy
Karen Palmer, Resources for the Future
Napaporn Phumaraphand, Electricity Generating Authority of Thailand
Larry Plumb, Verizon
Barbara Schlomann, Fraunhofer Institute for Systems and Innovation Research
Elizabeth Sendich, US Energy Information Administration
Marcel da Costa Siqueira, Electrobras, Brazil
Joël Vormus, CLER, France
Maarten van Werkhoven, IEA 4E
Rita Werle, IEA 4E

Internal reviewers included Jennifer Amann, Naomi Baum, Neal Elliott, Therese Langer, Steve Nadel, Lowell Ungar, and Suzanne Watson. We would also like to thank Fred

Grossberg for managing the editorial process, Miranda Kaplan, Sean O'Brien, and Roxanna Usher for copy editing, Eric Schwass for assistance with the graphics, and Glee Murray, Patrick Kiker, and Maxine Chikumbo for their help in launching this report.

Executive Summary

Energy efficiency is often the least-cost means of meeting new demand for energy. Governments that encourage investment in energy efficiency and implement supporting policies save citizens money, reduce dependence on energy imports, and decrease pollution. Yet energy efficiency remains massively underutilized globally despite its proven multiple benefits and its potential to become the single largest resource to meet growing energy demand worldwide.

The third edition of ACEEE's *International Energy Efficiency Scorecard* examines the efficiency policies and performance of 23 of the world's top energy-consuming countries. Together these countries represent 75% of all the energy consumed on the planet and over 80% of the world's gross domestic product (GDP) in 2013. We evaluated and scored each country's efficiency policies and how efficiently its buildings, industry, and transportation sectors use energy.

Compared to previous editions, this year's *Scorecard* gives more weight to policy actions, with the point allocation split 60/40 between policy and performance. Policy metrics highlight best practices implemented by a country, such as national energy savings targets, vehicle fuel economy standards, or energy efficiency standards for appliances. Performance metrics measure energy use per unit of activity or service extracted, for example, the average on-road miles per gallon (mpg) for passenger vehicles or the energy consumed per square foot of floor space in residential buildings.

We evaluated each country using 35 policy and performance metrics spread over 4 categories: buildings, industry, transportation, and overall national energy efficiency efforts. We allocated 25 points to each of these 4 categories and awarded the maximum number of points for each metric to at least 1 country.

Germany earned the highest overall score with 73.5 out of 100 possible points, followed closely by Italy and Japan, tied for second with 68.5 points. Germany scored the most points in the national efforts, buildings, and industry categories, while India tied with Italy and Japan for first place in transportation. The lowest-scoring country was Saudi Arabia with 15.5 points. Brazil and South Africa rounded out the bottom three, although with significantly higher scores of 32.5 and 33 points, respectively (see figure ES1 below).

Our results indicate that there are substantial opportunities for improvement in all the economies evaluated in this report. The average score was just 51 points. Low-scoring developing countries such as Brazil, South Africa, Thailand, and Mexico have great potential to build energy efficiency into their continued economic growth by implementing policies in their industrial, buildings, and transportation sectors. Their more developed counterparts could lead by example and implement ambitious policies that will further reduce energy consumption.

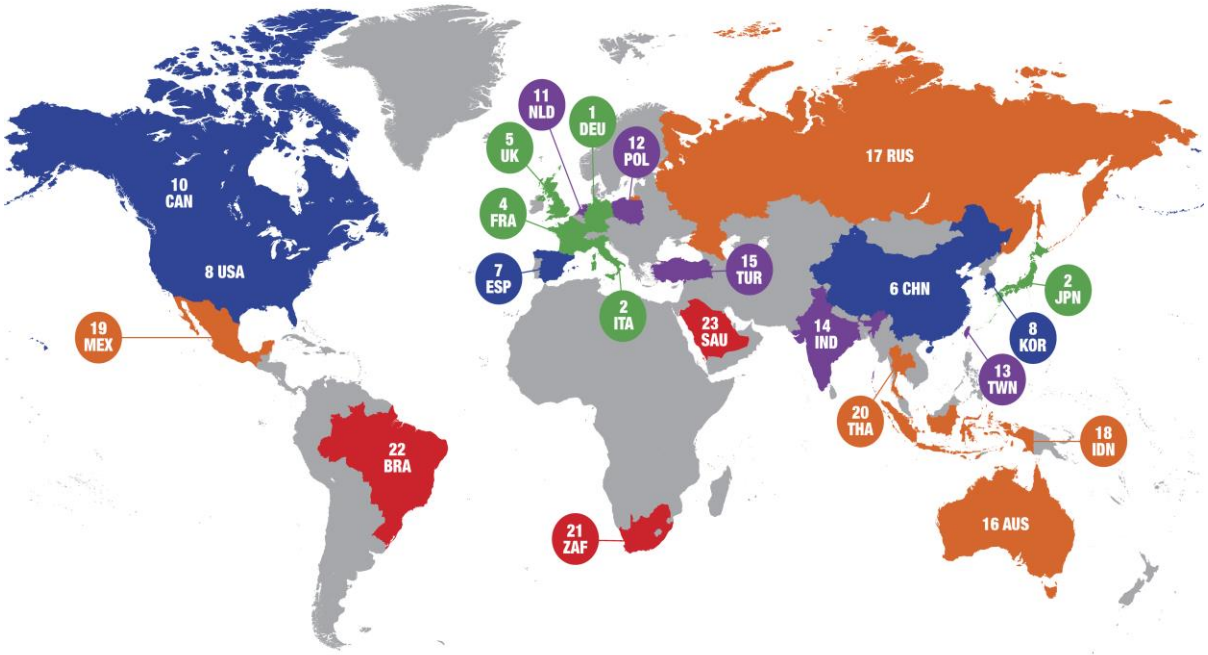


Figure ES1. Rankings by country

The United States ranked 8th out of 23 countries. Its score improved to 61.5 points from 42 points in the previous edition, in part due to better performance in the national efforts and buildings categories. US progress toward greater energy efficiency has been aided by more stringent fuel economy standards for light-duty and heavy-duty vehicles, comprehensive tax credit and loan programs to encourage efficiency, and voluntary partnerships between government and industry. The United States has more mandatory appliance and equipment standards than any other country we evaluated, covering more than 60 product categories.

Nevertheless US energy efficiency still falls behind Germany, Japan, Italy, France, the United Kingdom, China, and Spain. The United States can make even more progress in implementing efficiency policies and reducing energy consumption. This report offers a number of policy recommendations toward that end.

Introduction

Energy efficiency is often the least-cost means of meeting new demand for energy. Not only does it reduce overall energy consumption, it encourages development and creates jobs. Governments that encourage investment in energy efficiency and implement supporting policies save citizens money, reduce dependence on energy imports, and decrease pollution. Energy efficiency investments made by the 29 member countries of the International Energy Agency (IEA) since 1990 saved their citizens $550 billion in 2014 alone. These avoided costs of energy consumption included $80 billion saved in reduced fossil fuel imports, resulting in 10 billion tonnes of carbon dioxide (CO_2) emissions avoided between 1990 and 2015 (IEA 2015a).

Energy efficiency is particularly important given that the global demand for energy has risen rapidly. The world's total primary energy consumption more than doubled between 1973 and 2013. In 2013 the world consumed 13,541 million tonnes of oil equivalent (Mtoe) of which coal, oil, and natural gas supplied 81% (IEA 2015c). Global energy demand is projected to grow another 37% by 2040 (IEA 2014b). Yet energy efficiency remains massively underutilized globally despite its proven multiple benefits and its potential to become the single largest resource for meeting growing energy demand worldwide (IEA 2014a).

The 2016 International Energy Efficiency Scorecard examines the energy efficiency policies and performance of 23 of the world's top energy-consuming countries. Together these countries represent 75% of all the energy consumed on the planet and accounted for over 80% of the world's gross domestic product (GDP) in 2013 (World Bank 2016c, 2016e).

This third edition of the *Scorecard* serves three purposes. First, it presents readers with a basic comparison of energy use and efficiency policy efforts in the top energy-consuming countries. Second, it identifies a number of best practices and policies that countries can implement to take advantage of untapped efficiency potential. Last, it also shows where the United States stands on the global energy efficiency stage and provides recommendations for further policy improvements. We hope the report's findings will generate discussion among stakeholders to promote energy efficiency globally.

We used 35 metrics to evaluate each country's national commitment to energy efficiency as well as its efficiency policies and performance in the buildings, industry, and transportation sectors. We ranked the countries on each of the metrics and highlighted best practices in countries that performed well and areas for improvement in countries that did not. Although we recognize that a number of factors affect energy use including wealth, climate, geography, and demography, we largely avoided adjusting the data to reflect those impacts and only did so when the case for adjustments was compelling. To evaluate energy use across countries we present the data in the least processed form that allows for meaningful comparison.

Methodology

This section outlines the rationale we used to choose the countries we evaluated, the methodology we used to evaluate each country on the 35 metrics, and the differences in our ratings approach from the 2014 edition (Young et al. 2014).

This year we shifted our focus from evaluating the countries with the highest GDPs to the countries that are the top energy consumers worldwide. Figure 1 compares primary energy use in the countries we evaluated.

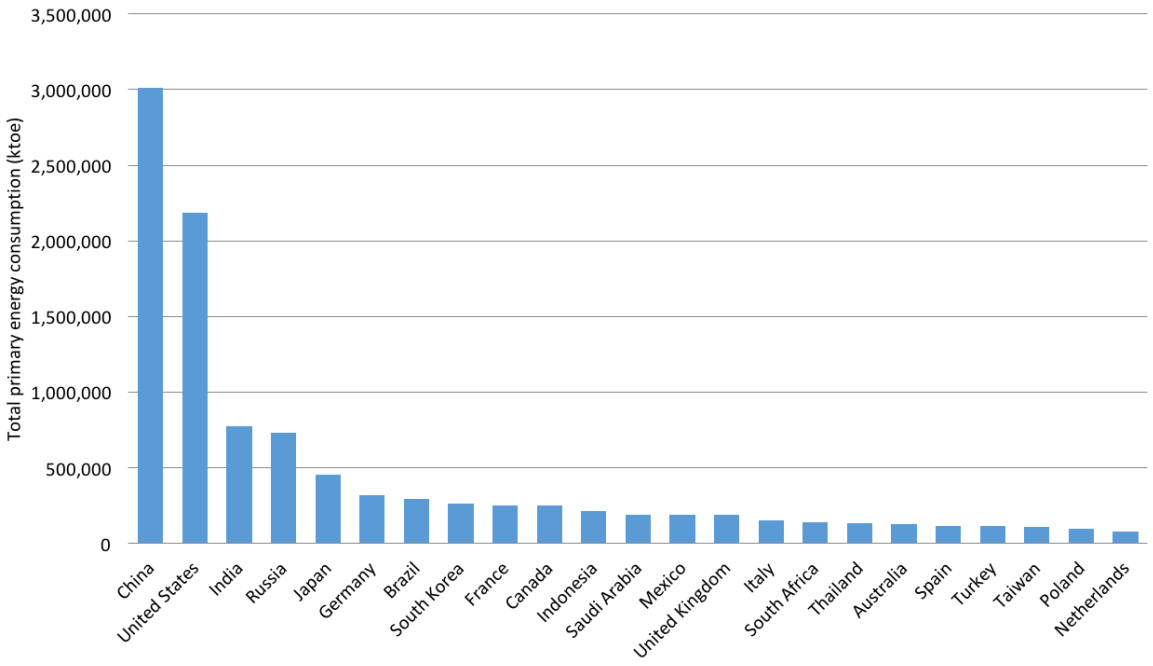


Figure 1. Total primary energy consumption of top energy consumers, in kilotonnes of oil equivalent (ktoe). Data are for 2013. ***Source:*** **IEA 2016f.**

We added eight new countries to our analysis this year: Indonesia, the Netherlands, Poland, Saudi Arabia, South Africa, Taiwan, Thailand, and Turkey. While Iran and Ukraine are also among the top 25 energy consumers (EIA 2012), we omitted them due to the inadequacy of the available data. We also dropped the European Union from our list because there were a number of discrepancies in the 2014 edition relating to how we scored the European Union in each category due to data limitations. Additionally, we already evaluate a growing number of European countries individually. Table 1 shows the population, market exchange rate GDP, and energy use by sector for each of our evaluated countries.

Table 1. GDP and energy consumption of top energy-consuming countries in 2013

Country	GDP (trillion USD; current MER)	Population	Total primary energy consumption (ktoe)	Total final energy consumption (ktoe)	Buildings total final energy consumption (ktoe)	Industry total final energy consumption (ktoe)	Transport total final energy consumption (ktoe)
Australia	1.56	23,125,868	129,141	80,793	17,425	25,226	31,141
Brazil	2.39	204,259,377	293,683	228,428	35,633	82,462	83,370
Canada	1.84	35,158,304	253,198	199,094	57,026	47,764	61,138
China	9.49	1,357,380,000	3,009,472	1,943,490	470,353	957,004	258,301
France	2.81	65,925,498	253,323	157,555	66,618	28,000	43,337
Germany	3.73	80,645,605	317,658	224,903	93,603	55,167	54,248
India	1.86	1,279,498,874	775,445	528,337	203,437	179,090	74,795
Indonesia	0.91	251,268,276	213,641	161,990	65,387	36,774	46,189
Italy	2.14	60,233,948	155,372	121,170	50,071	26,137	35,701
Japan	4.92	127,338,621	454,655	311,410	112,930	82,006	73,436
Mexico	1.26	123,740,109	191,274	118,177	21,421	34,721	51,126
Netherlands	0.85	16,804,432	77,391	61,645	19,560	12,300	11,071
Poland	0.53	38,040,196	97,589	66,981	28,450	14,382	15,518
Russia	2.08	143,506,911	730,890	434,487	137,656	123,655	93,533
Saudi Arabia	0.74	30,201,051	192,181	133,067	18,889	46,138	41,669
South Africa	0.37	53,157,490	141,271	74,320	21,184	26,444	18,772
South Korea	1.31	50,219,669	263,828	167,839	40,691	47,687	31,377
Spain	1.39	46,620,045	116,727	81,457	24,557	20,118	28,147
Taiwan	0.51	23,344,670	108,631	67,661	9,331	23,116	12,033
Thailand	0.39	67,451,422	134,065	95,803	17,455	29,896	22,627
Turkey	0.82	75,010,202	116,485	86,017	31,063	24,497	19,122
UK	2.68	64,106,779	190,952	129,033	57,829	23,353	39,059
US	16.77	316,497,531	2,188,363	1,495,068	470,844	261,046	607,951

Sources: IEA 2016e; World Bank 2016c; World Bank 2016e.

Whenever possible we collected data and indicators on energy consumption and energy efficiency policy from centralized, internationally recognized sources such as the IEA, the World Bank, the World Energy Council, the Organization for Economic Co-operation and Development (OECD), and the International Council on Clean Transportation (ICCT). We supplemented this information with country-level research by ACEEE staff. We sought the counsel of in-country and subject-matter experts by circulating data requests to confirm that we had accessed the most accurate information.

As table 1 indicates, we examined efficiency in the three largest end-use energy categories: buildings, industry, and transportation. We also evaluated, as a separate category, national efforts toward improving energy efficiency. In some cases we chose metrics based on the availability of relevant, accurate data.

Metrics are either policy or performance oriented. Policy metrics highlight best practices implemented by a country. They can be either qualitative or quantitative. Examples include national targets for energy efficiency, building and appliance labeling, and fuel economy standards for vehicles. The performance-oriented metrics measure energy use per unit of activity or service extracted; they are quantitative. Examples include the efficiency of thermal power plants, energy intensities of buildings and industry, and average on-road vehicle fuel economy.

We have changed the ratio of policy to performance metrics since the last edition, based on feedback on the *2014 Scorecard*. That edition saw a roughly 50/50 split in points awarded based on policy metrics and performance metrics. This year the point allocation is split 60/40 between policy and performance. This revised weighting reflects the fact that the performance metrics in part measure factors other than energy efficiency such as the local climate's impact on the degree to which buildings are heated or cooled.

The maximum possible score for a country was 100. We awarded up to 25 points in each of the 4 categories: national efforts, buildings, industry, and transportation. We allocated the points available within each category according to the recommendations of our expert advisers. We awarded the highest score available for a given metric to at least one country, which means that if any country were to emulate the top practices and results in each metric, it could obtain a score of 100. (However no country scored full points on all the metrics, indicating that all of them have room for improvement.) Table 2 presents a snapshot of the metrics and point allocation. We describe the metrics in greater detail in subsequent chapters.

Table 2. Metrics for all sectors

Type of metric	Metric	2014 points	2016 points
National efforts			
Performance	Change in energy intensity between 2000 and 2013	6	6
Policy	Spending on energy efficiency	5	5
Policy	Energy savings goals	3	3
Performance	Efficiency of thermal power plants	3	3
Policy	Tax credits and loan programs	3	2
Policy	Spending on energy efficiency research and development	2	2
Performance	Size of the energy service companies (ESCOs) market	2	2
Policy	Water efficiency policy	1	1
Policy	Data availability*	–	1

Type of metric	Metric	2014 points	2016 points
Buildings			
Policy	Appliance and equipment standards	5	5
Policy	Residential building codes	3	4
Policy	Commercial building codes	3	4
Policy	Building retrofit policies	2	4
Policy	Building labeling	2	2
Policy	Appliance and equipment labeling	2	2
Performance	Energy intensity in residential buildings	4	2
Performance	Energy intensity in commercial buildings	4	2
Industry			
Performance	Energy intensity of the industrial sector	8	6
Policy	Voluntary energy performance agreements with manufacturers	3	3
Policy	Policy to encourage energy management*	–	2
Policy	Minimum efficiency standards for electric motors*	–	2
Policy	Mandate for plant energy managers	2	2
Policy	Mandatory energy audits	2	2
Policy	Investment in manufacturing research and development (R&D)	2	2
Performance	Share of combined heat and power (CHP) in total installed capacity	6	2
Policy	Policy to encourage CHP*	–	2
Performance	Agriculture energy intensity	2	2
Transportation			
Policy	Fuel economy standards for light-duty vehicles	4	4
Performance	Fuel economy of light-duty vehicles	3	3
Policy	Fuel economy standards for heavy-duty tractor trucks	3	3
Performance	Vehicle miles traveled per capita	3	3
Performance	Freight transport per unit of economic activity	3	3
Performance	Energy intensity of freight transport	3	3
Performance	Use of public transit	3	3
Policy	Investment in rail transit versus roads	3	3
Total		**100**	**100**

* New metric added since the last edition of this report

Data and Analysis Limitations

It is challenging to find a methodology that adequately captures energy efficiency efforts and allows for comparison across a range of countries. Physical factors such as geographic size, climate, elevation, and availability of natural resources determine to a great extent the

energy a country uses. Climate heavily influences the energy used for heating and cooling buildings, while land area and topography affect energy used for transportation.

Economic structure is another factor that governs energy use. Agriculture- and labor-based economies tend to have lower energy consumption than industrialized ones. Among industrialized countries manufacturing economies are generally more energy intensive than those that are service based. Changes to the economic structure of a country over time may impact energy use. In general however we avoided adjusting for these changes unless we felt it was absolutely necessary.

Demographic composition and population density also affect overall energy consumption, as do other social factors such as income levels and energy inequity. For example, a country with high energy use among some users but with little energy access can appear energy efficient in a comparison of energy use per capita across countries. These conditions are difficult to control for, and we were not always able to account for them in our scoring methodology. In general we made only modest adjustments to raw data to enable basic comparisons across countries.

The most significant limiting factor for our analysis was the availability of consistent, comprehensive data. Not all countries track data specific to energy efficiency, such as the energy consumption per square foot of residential-building area or the energy intensity of freight transportation. In a few cases in which data were unavailable, we assigned scores based on our best estimates from related information and expert opinion; we indicate these cases in our presentation of results. In some cases our choice of metrics to cover key aspects of energy efficiency and energy use in each sector was limited by a lack of data consistency. Additionally, there are many different ways to evaluate energy efficiency in a country. Our methodology, while reasonable, could have used a variety of different metrics or different relative values for the metrics, which would have resulted in changes in the rankings.

Finally, to a small extent our analysis includes policy efforts that emerge from subnational governments where such policies affect the country as a whole. These efforts can sometimes be as effective as or even more effective than national policies. However their relative importance varies among nations, and the widespread collection and analysis of regional information are beyond the scope of this report.

Results

OVERALL

Germany earned the top spot this year with a score of 73.5 points. Closely following were Japan and Italy, tied for second place with a score of 68.5. The lowest-scoring country was Saudi Arabia with a score of 15.5 points. Brazil and South Africa rounded out the bottom three, although with significantly higher scores of 32.5 and 33 points, respectively.[1]

[1] We recognize that for the EU countries, many of the policies evaluated in this report stem from directives issued by the European Union. However, because each country is free to interpret these directives differently, we scored them on their individual actions.

For a number of the lower-scoring countries, particularly Saudi Arabia, scores were not necessarily representative of national efforts on energy efficiency because of problems we encountered in our efforts to find reasonable data. See Appendix B for a summary of each country's results, policy areas in which the country is strongest, areas for improvement, and resources for further information.

Figure 2 displays the overall rankings for our evaluated countries. Table 3 lists the scores for all 23 countries by metric. Table 4 shows country rankings and scores in each of the four categories: national efforts, buildings, industry, and transportation. Figure 3 shows the results from table 3 by sector for each country, illustrating the large overall difference between the top-ranking and lowest-ranking countries. Figure 3 also shows that all countries have substantial room for improvement.

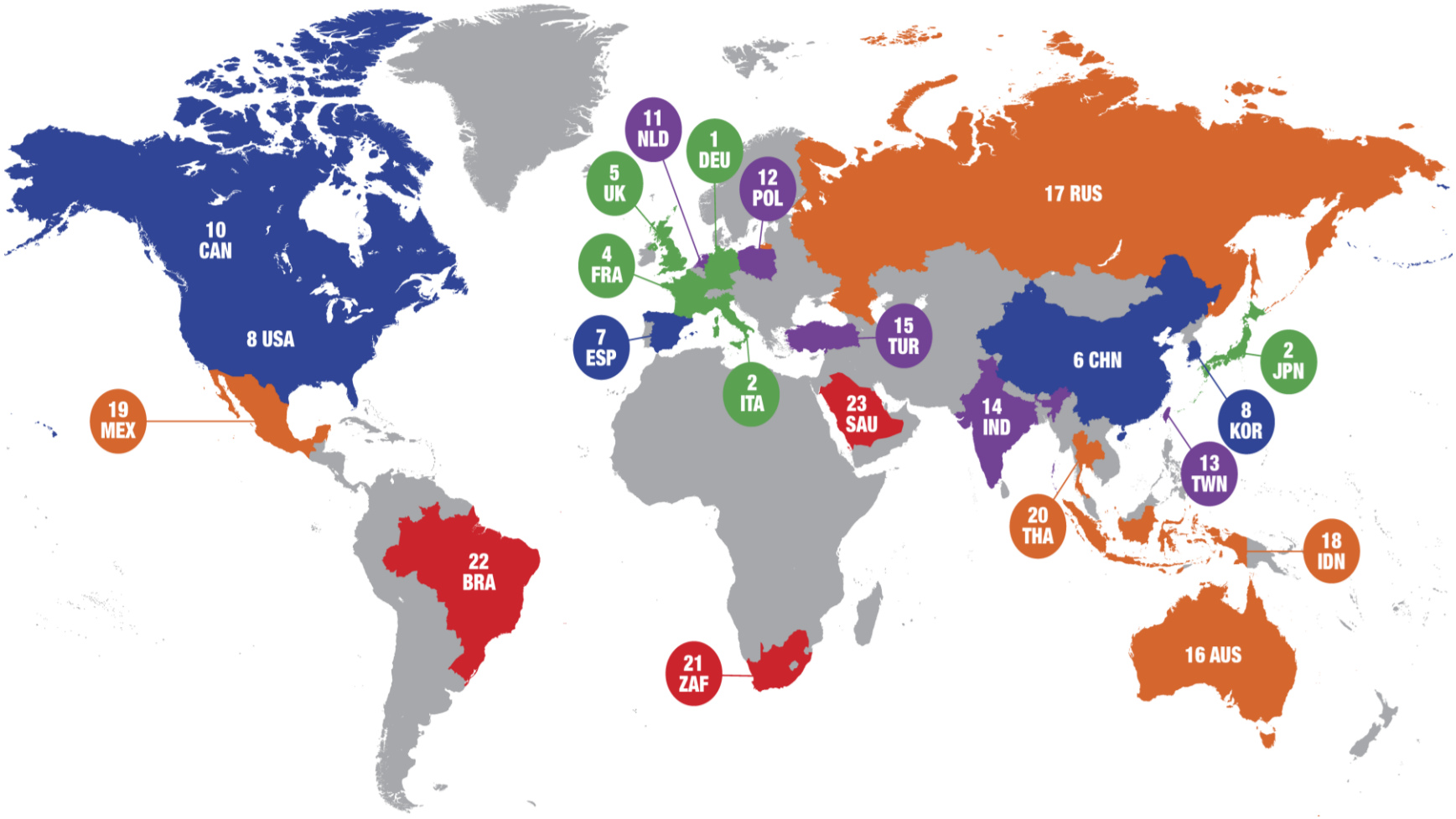


Figure 2. Rankings by country

Table 3. Scores for all metrics by country

Metric	Max. points	Australia	Brazil	Canada	China	France	Germany	India	Indonesia	Italy	Japan	Mexico	Netherlands
National efforts total	**25**	**13**	**7**	**17**	**16**	**18**	**21**	**11.5**	**8**	**16**	**19**	**5.5**	**15**
Change in energy intensity	6	4	1	5	5	3	4	5	6	2	5	0	2
Spending on energy efficiency	5	1	0	2	3	3	5	0	0	4	1	0	1
Energy savings goals	3	3	1	1	2	3	3	2	1	2	3	1	3
Efficiency of thermal power plants	3	1	2	2	1	1	2	0	0	2	3	2	3
Tax credits and loan programs	2	0	1	2	2	2	2	2	0	2	2	1	2
Spending on energy efficiency R&D	2	1.5	1.5	2	0	2	2	0	0	1	2	0	2
Size of the ESCO market	2	0.5	0	1	1.5	2	2	1	0	1	1	0.5	0
Water efficiency policy	1	1	0	1	1	1	0	1	1	1	1	0	1
Data availability	1	1	0.5	1	0.5	1	1	0.5	0	1	1	1	1
Buildings total	**25**	**15.5**	**6.5**	**17.5**	**18**	**18**	**19.5**	**7.5**	**5.5**	**17**	**13**	**11**	**15**
Appliance and equipment standards	5	1	1	5	5	2	2	0	0	2	2	3	2
Residential building codes	4	4	0	3.5	3.5	3	4	1	0	3	3.5	0	3
Commercial building codes	4	4	0	3.5	3	3	4	2.5	2	3	2	3	2.5
Building retrofit policies	4	2	0	3	1	4	4	0	0	3	2	0	3
Building labeling	2	1	0	0.5	1	2	2	1	0	2	0	0	1
Appliance and equipment labeling	2	1.5	1.5	1	2	2	2	1	1	2	1.5	1	2
Energy intensity in residential buildings	2	0.5	2	0.5	1	0.5	0.5	1	1	0.5	1	2	0.5
Energy intensity in commercial buildings	2	1.5	2	0.5	1.5	1.5	1	1	1.5	1.5	1	2	1
Industry total	**25**	**5.5**	**6**	**13.5**	**15**	**16.5**	**21**	**13.5**	**16**	**19.5**	**20.5**	**11.5**	**16**
Energy intensity of industry	6	2	1	4	0	5	5	0	6	5	5	5	5
Voluntary agreements with manufacturers	3	0	0	3	3	3	3	3	2	3	2	0	2
Mandate for energy managers	2	0	0	0	2	0	0	2	2	2	2	0	0
Mandatory energy audits	2	0	0	0	2	2	2	2	2	2	2	0	2
CHP installed capacity	2	0.5	0.5	0.5	1	0	1.5	0.5	0	1.5	0	0	2
CHP policy	2	0	1	1	1	1	2	2	0	1	2	1	1
Standards for motors	2	1	1	2	1	2	2	0	0	2	2	2	2
Energy management policy	2	0	0	2	2	1	2	2	2	1	2	2	1
Investment in manufacturing R&D	2	1	1	0.5	1	1.5	1.5	0	0	0.5	2	0	1
Energy intensity of agriculture	2	1	1.5	0.5	2	1	2	2	2	1.5	1.5	1.5	0
Transportation total	**25**	**7**	**13**	**11**	**15**	**15**	**12**	**16**	**8**	**16**	**16**	**9**	**12**
Fuel economy standards for light-duty vehicles	4	0	2	3	3	4	4	3	0	4	3	1	4
Fuel economy of light-duty vehicles	3	0	2	1	1	3	2	3	2	3	3	1	2
Fuel economy standards for heavy-duty trucks	3	0	0	3	2	0	0	0	0	0	1	0	0
Vehicle miles traveled per capita	3	1	2	0	3	2	1	3	3	3	1	2	1
Freight transport per unit of economic activity	3	1	0	1	0	2	1	0	0	2	3	1	2
Energy intensity of freight transport	3	3	2	2	2	1	2	2	1	0	1	0	1
Use of public transit	3	1	3	1	3	1	1	3	2	1	3	3	1
Investment in rail transit versus roads	3	1	2	0	1	2	1	2	0	3	1	1	1
Total	**100**	**41**	**32.5**	**59**	**64**	**67.5**	**73.5**	**48.5**	**37.5**	**68.5**	**68.5**	**37**	**58**

Metric	Max. points	Poland	Russia	Saudi Arabia	South Africa	South Korea	Spain	Taiwan	Thailand	Turkey	UK	US
National efforts total	**25**	**15**	**11**	**2.5**	**8**	**14.5**	**16**	**13**	**8.5**	**6.5**	**15.5**	**16.5**
Change in energy intensity	6	6	6	0	3	4	4	2	0	2	6	5
Spending on energy efficiency	5	0	0	0	0	0	1	2	0	0	1	2
Energy savings goals	3	3	1	1	1	2	3	1	1	1	2	1
Efficiency of thermal power plants	3	1	0	0	1	2	3	2	3	2	2	2
Tax credits and loan programs	2	2	2	0	2	2	1	1	2	0	1	2
Spending on energy efficiency R&D	2	0.5	0	0.5	0	1	0.5	1.5	0	0	1.5	2
Size of the ESCO market	2	0.5	1	0	0	1.5	1.5	2	1.5	0	1	1.5
Water efficiency policy	1	1	0	1	1	1	1	1	1	1	0	0
Data availability	1	1	1	0	0	1	1	0.5	0	0.5	1	1
Buildings total	**25**	**15**	**6**	**5**	**11**	**14.5**	**17.5**	**13**	**5**	**15**	**16**	**18.5**
Appliance and equipment standards	5	2	0	0	0	3	2	1	0	2	2	5
Residential building codes	4	2.5	1.5	1.5	4	3.5	3	2.5	0	2.5	3	3.5
Commercial building codes	4	2.5	1.5	1.5	4	3.5	3	2.5	2.5	2.5	3	3.5
Building retrofit policies	4	3	0	0	0	2	3	3	1	3	2	3
Building labeling	2	2	1	0	0	0	1	0	0	2	2	0.5
Appliance and equipment labeling	2	2	1.5	1.5	1	2	2	1.5	0.5	2	2	1
Energy intensity in residential buildings	2	0.5	0	0.5	0.5	0.5	1.5	1	1	0.5	0.5	1
Energy intensity in commercial buildings	2	0.5	0.5	0	1.5	0	2	1.5	0	0.5	1.5	1
Industry total	**25**	**11.5**	**10**	**4**	**5**	**18.5**	**15.5**	**16**	**13**	**14**	**19.5**	**14.5**
Energy intensity of industry	6	3	1	1	0	4	4	3	2	3	6	3
Voluntary agreements with manufacturers	3	0	3	0	3	3	3	0	3	3	3	2
Mandate for energy managers	2	0	0	0	0	0	0	2	2	2	0	0
Mandatory energy audits	2	2	0	0	0	2	2	2	2	0	2	0
CHP installed capacity	2	1.5	2	0	0	1	0.5	1.5	0.5	0.5	0.5	0.5
CHP policy	2	1	0	0	1	1	0	1	0	0	1	2
Standards for motors	2	2	0	1	0	2	2	1	0	1	2	2
Energy management policy	2	1	2	0	0	2	2	2	2	2	2	2
Investment in manufacturing R&D	2	0	0.5	0	0	2	0.5	1.5	0	0.5	1.5	2
Energy intensity of agriculture	2	1	1.5	2	1	1.5	1.5	2	1.5	2	1.5	1
Transportation total	**25**	**12**	**11**	**4**	**9**	**14**	**13**	**9**	**10**	**11**	**14**	**12**
Fuel economy standards for light-duty vehicles	4	4	0	2	0	4	4	0	0	0	4	3
Fuel economy of light-duty vehicles	3	2	1	0	3	1	2	0	3	3	3	0
Fuel economy standards for heavy-duty trucks	3	0	0	0	0	0	0	0	0	0	0	3
Vehicle miles traveled per capita	3	1	2	2	3	2	1	2	3	3	1	0
Freight transport per unit of economic activity	3	1	0	0	0	2	1	3	1	1	2	1
Energy intensity of freight transport	3	2	3	0	0	0	1	0	0	0	0	3
Use of public transit	3	2	2	0	1	3	1	1	2	3	1	1
Investment in rail transit versus roads	3	0	3	0	2	2	3	3	1	1	3	1
Total	**100**	**53.5**	**38**	**15.5**	**33**	**61.5**	**62**	**51**	**36.5**	**46.5**	**65**	**61.5**

Table 4. Final scores and ranking by country

Total (100 points)			National efforts (25 points)			Buildings (25 points)			Industry (25 points)			Transportation (25 points)		
Country	Score	Rank	Country	Score	Rank	Country	Score	Rank	Country	Score	Rank	Country	Score	Rank
Germany	73.5	1	Germany	21	1	Germany	19.5	1	Germany	21	1	India	16	1
Japan	68.5	2	Japan	19	2	US	18.5	2	Japan	20.5	2	Italy	16	1
Italy	68.5	2	France	18	3	China	18	3	UK	19.5	3	Japan	16	1
France	67.5	4	Canada	17	4	France	18	3	Italy	19.5	3	China	15	4
UK	65	5	US	16.5	5	Spain	17.5	5	South Korea	18.5	5	France	15	4
China	64	6	China	16	6	Canada	17.5	5	France	16.5	6	South Korea	14	6
Spain	62	7	Italy	16	6	Italy	17	7	Indonesia	16	7	UK	14	6
South Korea	61.5	8	Spain	16	6	UK	16	8	Netherlands	16	7	Brazil	13	8
US	61.5	8	UK	15.5	9	Australia	15.5	9	Taiwan	16	7	Spain	13	8
Canada	59	10	Netherlands	15	10	Netherlands	15	10	Spain	15.5	10	Germany	12	10
Netherlands	58	11	Poland	15	10	Turkey	15	10	China	15	11	Netherlands	12	10
Poland	53.5	12	South Korea	14.5	12	Poland	15	10	US	14.5	12	Poland	12	10
Taiwan	51	13	Taiwan	13	13	South Korea	14.5	13	Turkey	14	13	US	12	10
India	48.5	14	Australia	13	13	Taiwan	13	14	India	13.5	14	Canada	11	14
Turkey	46.5	15	India	11.5	15	Japan	13	14	Canada	13.5	14	Russia	11	14
Australia	41	16	Russia	11	16	Mexico	11	16	Thailand	13	16	Turkey	11	14
Russia	38	17	Thailand	8.5	17	South Africa	11	16	Poland	11.5	17	Thailand	10	17
Indonesia	37.5	18	Indonesia	8	18	India	7.5	18	Mexico	11.5	17	Mexico	9	18
Mexico	37	19	South Africa	8	18	Brazil	6.5	19	Russia	10	19	South Africa	9	18
Thailand	36.5	20	Brazil	7	20	Russia	6	20	Brazil	6	20	Taiwan	9	18
South Africa	33	21	Turkey	6.5	21	Indonesia	5.5	21	Australia	5.5	21	Indonesia	8	21
Brazil	32.5	22	Mexico	5.5	22	Saudi Arabia	5	22	South Africa	5	22	Australia	7	22
Saudi Arabia	15.5	23	Saudi Arabia	2.5	23	Thailand	5	22	Saudi Arabia	4	23	Saudi Arabia	4	23

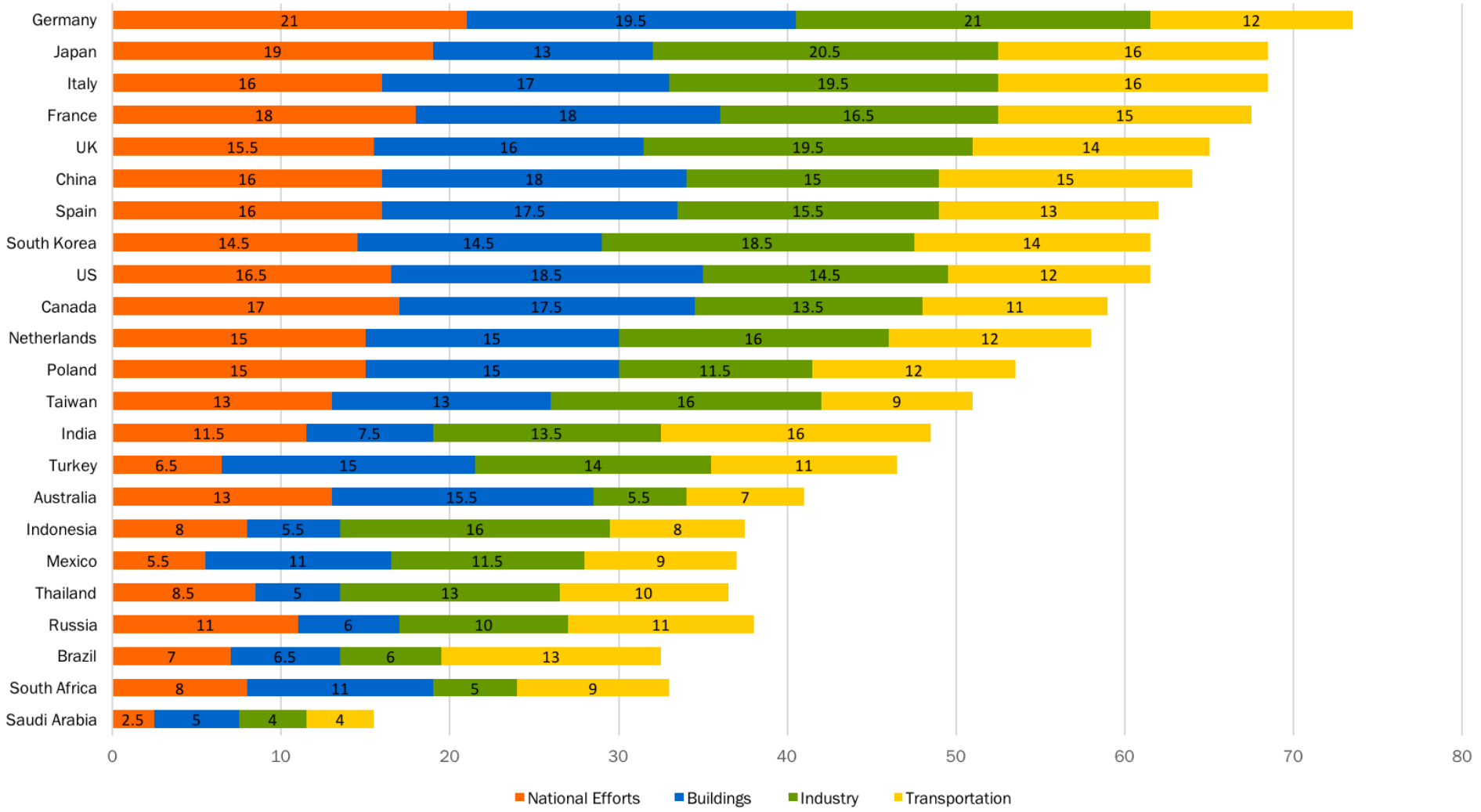


Figure 3. Overall scores and rankings

POLICY METRICS

While sector scores are informative, a look at the breakdown in how countries score on individual policy versus performance metrics is also revealing. We see different leaders emerging when we rank countries according to the policy-related metrics. Table 5 shows the breakdown of points for these metrics.

Table 5. Point allocation for policy metrics

Metric	2014 points	2016 points
National efforts		
Spending on energy efficiency	5	5
Energy savings goals	3	3
Tax credits and loan programs	3	2
Spending on energy efficiency R&D	2	2
Water efficiency policy	1	1
Data availability	–	1
Buildings		
Appliance and equipment standards	5	5
Residential building codes	3	4
Commercial building codes	3	4
Building retrofit policies	2	4
Building labeling	2	2
Appliance and equipment labeling	2	2
Industry		
Voluntary agreements with manufacturers	3	3
Energy management policy	–	2
Standards for motors	–	2
Mandate for energy managers	2	2
Mandatory energy audits	2	2
Investment in manufacturing R&D	2	2
CHP policy	–	2
Transportation		
Fuel economy standards for light-duty vehicles	4	4
Fuel economy standards for heavy-duty tractor trucks	3	3
Investment in rail transit versus roads	3	3
Total	**50**	**60**

Table 6 shows the rankings.

Table 6. Countries ranked by total score on policy metrics (60 possible points)

	Points	Rank
Germany	48.5	1
France	44.5	2
Italy	44.5	2
China	42	4
US	41.5	5
Canada	40	6
Japan	40	6
South Korea	39	8
UK	39	8
Spain	38	10
Netherlands	37.5	11
Poland	31.5	12
Taiwan	30	13
India	27	14
Turkey	26	15
Australia	24	16
South Africa	19	17
Russia	18	18
Thailand	18	18
Mexico	17	20
Brazil	13.5	21
Indonesia	13	22
Saudi Arabia	10	23

Table 6 shows that many EU countries scored the highest on policy metrics, along with China, the United States, and Canada. These countries are taking the most action on energy efficiency through policies and programs. The EU countries led for their buildings and industry efficiency policies, while the United States is a leader in the buildings sector. Most of the countries that scored well on the policy metrics have some sort of unifying national energy-reduction goal in place.

PERFORMANCE METRICS

Table 7 shows the breakdown of points allocated to performance metrics, and table 8 shows the country scores.

Table 7. Point allocation for performance metrics

Metric	2014 points	2016 points
National efforts		
Change in energy intensity between 2000 and 2013	6	6
Efficiency of thermal power plants	3	3
Size of the ESCO market	2	2
Buildings		
Energy intensity in residential buildings	4	2
Energy intensity in commercial buildings	4	2
Industry		
Energy intensity of the industrial sector	8	6
CHP installed capacity	6	2
Energy intensity of agriculture	2	2
Transportation		
Fuel economy of light-duty vehicles	3	3
Vehicle miles traveled per capita	3	3
Freight transport per unit of economic activity	3	3
Energy intensity of freight transport	3	3
Use of public transit	3	3
Total	**50**	**40**

Table 8. Countries ranked by total score on performance metrics (40 possible points)

	Points	Rank
Japan	28.5	1
UK	26	2
Germany	25	3
Indonesia	24.5	4
Italy	24	5
Spain	24	5
France	23	7
South Korea	22.5	8
China	22	9
Poland	22	9
India	21.5	11
Taiwan	21	12
Netherlands	20.5	13
Turkey	20.5	13
Mexico	20	15
Russia	20	15
US	20	15
Brazil	19	18
Canada	19	18
Thailand	18.5	20
Australia	17	21
South Africa	14	22
Saudi Arabia	5.5	23

Table 8 shows a more mixed group of leaders. While the EU nations again did well, so did a number of less developed Asian countries such as Indonesia, largely because their economies are not nearly as energy intensive as some of their more developed counterparts. The EU nations that topped this list were more likely to do well on performance metrics because of their targeted energy efficiency policies. However, as discussed earlier, rating countries on their energy performance is very difficult given the number of factors that impact energy use and the vast differences in demography, climate, and economic conditions between nations. The combination of policy and performance metrics gives us a more complete picture of the progress a given country is making on energy efficiency.

National Efforts

In the national efforts section we examined overall energy efficiency performance across all sectors of the economy as well as the national government's commitment to and leadership on efficiency. We evaluated the change in energy intensity in each country relative to its GDP, and we also scored related cross-sectoral policies. Such policies included financial investments in energy efficiency programs in general, and in research and development (R&D) in emerging technologies specifically. We also scored countries on their national energy-saving targets and their tax incentives and loan programs aimed at engaging the private sector. We evaluated the total market size of energy service companies (ESCOs), which exemplify business models dedicated to advancing energy efficiency. We also compared the efficiencies of thermoelectric power plants. Last, we included a metric for water efficiency policy to indicate savings at the intersection of water and energy use. This year, for the first time, we awarded an extra point to countries that track and disclose information related to energy efficiency, to emphasize the importance of data availability.

For the third time in a row Germany earned the top spot in the national efforts category, with 21 out of a possible 25 points. Japan and France followed closely with 19 and 18 points, respectively. The EU countries stood out for having aggressive national energy savings targets as well as programs such as loans and tax incentives to encourage private investment in energy efficiency. Germany earned the maximum possible points for spending on energy efficiency, highlighting the government's dedication to reducing overall consumption. Japan's performance in this section results from high scores on the thermoelectric-efficiency metric as well as strong performances in R&D investment and tax incentives. In addition, Japan's energy intensity fell by 21% between 2000 and 2013, earning the country 5 out of a maximum 6 points. It is worth noting that the Fukushima nuclear accident in 2011 likely had a significant impact on energy intensity during this period.

The lowest scorers in this section were Saudi Arabia, Mexico, and Turkey. The United States ranked fifth out of the 23 evaluated countries, scoring well on energy-intensity reduction and energy efficiency spending. Table 9 shows national efforts scores by country.

Table 9. National efforts scores by country

Country	Total score	Change in energy intensity	Energy efficiency spending	Energy savings goals	Tax credits and loan programs	Thermal power plant efficiency	Energy efficiency R&D spending	Size of ESCOs market	Water efficiency policy	Data availability
Max. score	**25**	**6**	**5**	**3**	**2**	**3**	**2**	**2**	**1**	**1**
Germany	21	4	5	3	2	2	2	2	0	1
Japan	19	5	1	3	2	3	2	1	1	1
France	18	3	3	3	2	1	2	2	1	1
Canada	17	5	2	1	2	2	2	1	1	1
US	16.5	5	2	1	2	2	2	1.5	0	1
China	16	5	3	2	2	1	0	1.5	1	0.5
Italy	16	2	4	2	2	2	1	1	1	1
Spain	16	4	1	3	1	3	0.5	1.5	1	1
UK	15.5	6	1	2	1	2	1.5	1	0	1
Netherlands	15	2	1	3	2	3	2	0	1	1
Poland	15	6	0	3	2	1	0.5	0.5	1	1
South Korea	14.5	4	0	2	2	2	1	1.5	1	1
Australia	13	4	1	3	0	1	1.5	0.5	1	1
Taiwan	13	2	2	1	1	2	1.5	2	1	0.5
India	11.5	5	0	2	2	0	0	1	1	0.5
Russia	11	6	0	1	2	0	0	1	0	1
Thailand	8.5	0	0	1	2	3	0	1.5	1	0
Indonesia	8	6	0	1	0	0	0	0	1	0
South Africa	8	3	0	1	2	1	0	0	1	0
Brazil	7	1	0	1	1	2	1.5	0	0	0.5
Turkey	6.5	2	0	1	0	2	0	0	1	0.5
Mexico	5.5	0	0	1	1	2	0	0.5	0	1
Saudi Arabia	2.5	0	0	1	0	0	0.5	0	1	0

New in this section

For this edition of the report we calculated change in energy intensity using primary energy, whereas in 2014 we used final energy consumed. Primary energy includes upstream energy use and takes into account inefficiencies in generation, transmission, and distribution. Final energy is the end-use consumption as seen on energy bills. This section also has a new metric called data availability. We awarded up to one point to a country based on whether it tracked and reported energy efficiency information.

CHANGE IN ENERGY INTENSITY (6 POINTS)

Energy intensity is the energy consumed by each country annually to produce its total economic output. We calculated energy intensity as the total primary energy consumed per dollar of market exchange rate GDP. The lower the energy intensity, the higher the energy efficiency of the economy. We ranked countries by comparing improvement in energy intensity between 2000 and 2013. A country's energy intensity can vary from year to year due to a number of factors including shifts in economic composition and structure. Evaluating the change in intensity over time allows us to account for some of that fluctuation and better evaluate the impact of efficiency on energy use. Note that our results differ from those in the previous edition of the *Scorecard*, which reported changes in intensity based on final energy consumed per dollar of real GDP, as opposed to primary energy. However we continue to use 2000 as a starting point for our analysis to maintain some consistency. In addition, a reduction in energy intensity must not be mistaken as a reduction in total energy consumption. The total energy consumption of many countries was higher in 2013 than in 2000 (IEA 2016f).

Countries with a reduction of 30% or more in primary energy intensity between 2000 and 2013 received 6 points. Those with a reduction of at least 20% earned 5 points; at least 15% earned 4 points; at least 10% earned 3 points; at least 5% earned 2 points; and countries that saw a reduction in energy intensity of anywhere between 0 and 5% scored 1 point.

Table 10 shows the scores for each country.

Table 10. Scores for percentage change in primary energy intensity

Country	Percentage change in energy intensity, 2000–13	Score
Russia	-32.6%	6
Indonesia	-30.7%	6
UK	-30.6%	6
Poland	-30.2%	6
India	-28.9%	5
China	-24.9%	5
US	-23.0%	5
Canada	-22.1%	5
Japan	-21.1%	5
Spain	-18.9%	4
Australia	-18.6%	4
Germany	-17.3%	4
South Korea	-16.6%	4

Country	Percentage change in energy intensity, 2000–13	Score
South Africa	-14.5%	3
France	-13.4%	3
Turkey	-9.4%	2
Italy	-8.6%	2
Taiwan	-8.5%	2
Netherlands	-7.2%	2
Brazil	-0.2%	1
Saudi Arabia	0.4%	0
Mexico	0.9%	0
Thailand	6.5%	0

Sources: IEA 2016e; World Bank 2016b.

ENERGY EFFICIENCY SPENDING (5 POINTS)

We scored this metric based on the total investments in energy efficiency by the national government and the utility sector. In some countries the national government controls the utility sector, whereas in others, notably the United States, the utility sector is primarily regulated by states. Therefore, to be able to compare countries, we combined spending by utilities and by the national government in each country into a single expenditure. While this metric does not measure how effectively the money is spent, it is an indication of overall commitment to energy efficiency.

The data for this metric were some of the most challenging to collect. In some cases we used publicly available information about national spending, while in other cases we averaged budgets for government and utility programs that span multiple years. When we used multiyear budgets, we divided them by the lifetime of the programs to derive an annual figure. Many countries do not track separate investment data for utility spending on energy efficiency. In these cases we assumed that the utilities had small efficiency budgets relative to government investment.

We awarded 5 points for per capita spending of at least $100, 4 points for at least $75 per person, 3 points for at least $25, 2 points for at least $15, and 1 point for at least $5. Table 11 reports total government and utility spending in US dollars as well as spending per capita. The figures approximate the annual spending on energy efficiency in 2013 per person in each country.

Table 11. Scores for spending on energy efficiency

Country	Spending on energy efficiency ($/capita)	Score
Germany	$318.49	5
Italy	$81.61	4
France	$42.05	3
China	$29.47	3
Canada	$24.47	2
US	$18.96	2
Taiwan	$18.00	2
UK	$12.50	1
Spain	$10.23	1
Australia	$8.41	1
Netherlands	$7.44	1
Japan	$5.15	1
Brazil	$3.29	0
Mexico	$3.03	0
South Korea	$2.07	0
Indonesia	$0.40	0
Russia	$0.23	0
India	$0.10	0
Poland	$0.00	0
Saudi Arabia	$0.00	0
South Africa	$0.00	0
Thailand	$0.00	0
Turkey	$0.00	0

Sources: IEA 2015a; IEA 2016d.

ENERGY EFFICIENCY R&D SPENDING (2 POINTS)

To complement the energy efficiency spending metric, we included a more narrowly defined metric for per capita investment in energy efficiency R&D by the national government. These data are much more readily available.

We gave 2 points for per capita spending of at least $3, 1.5 points for at least $2 per person, 1 point for at least $1 per person, and 0.5 point for at least 10 cents per person. Table 12 shows the scores on this metric by country.

Table 12. Scores for spending on energy efficiency R&D

Country	Spending on energy efficiency R&D ($/capita)	Score
Germany	$4.70	2
US	$3.99	2
Netherlands	$3.86	2
Canada	$3.70	2
Japan	$3.30	2
France	$3.24	2
Australia	$2.99	1.5
UK	$2.65	1.5
Brazil	$2.27	1.5
Taiwan	$2.04	1.5
South Korea	$1.78	1
Italy	$1.57	1
Saudi Arabia	$0.85	0.5
Poland	$0.80	0.5
Spain	$0.20	0.5
Turkey	$0.07	0
South Africa	$0.01	0
China	$0.00	0
India	$0.00	0
Indonesia	$0.00	0
Mexico	$0.00	0
Russia	$0.00	0
Thailand	$0.00	0

Sources: IEA 2016c; ACEEE Taiwan data request.

It should be noted that due to the inconsistencies in the availability of data on national energy efficiency spending, it is possible that some of the results include energy efficiency R&D expenditure in total efficiency spending. There is likely some overlap in the United States, for instance, because national spending is partly based on the budget of the US Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy, which is tasked with investing in energy efficiency R&D and clean energy technology.

ENERGY SAVINGS GOALS (3 POINTS)

Energy savings goals spur innovation and articulate national priorities on energy efficiency across all sectors of an economy. These goals help measure progress toward a target,

making energy efficiency more tangible and yielding quantifiable results (ACEEE 2016). We awarded 3 points for goals requiring energy savings of more than 1% of a country's overall energy consumption per year. We awarded 2 points to countries with mandatory energy savings goals of less than 1% of overall energy consumption. Countries received 1 point for an energy-intensity target or a greenhouse gas (GHG)–reduction target. Most countries had at least a GHG reduction target from their commitments toward reducing emissions to the United Nations Framework Convention on Climate Change (UNFCC). Table 13 below shows the scores for energy savings goals.

TAX INCENTIVES AND LOAN PROGRAMS (2 POINTS)

This metric scored a government's commitment to encouraging private investment in energy efficiency. Energy efficiency investments more than pay for themselves over time, but the upfront cost of the technology, upgrade, or program is a common barrier. Government loan programs and tax credits can help lower or spread out these upfront costs, which better equips projects to pay back their costs. These incentives can also make market conditions for energy efficiency more favorable, attracting additional private investment (ACEEE 2016).

We gave the full 2 points to countries with both multisector loan programs and multisector tax incentives, and 1 point to countries having one or the other. We awarded 0.5 point for tax incentives or loan programs available for just one sector. Table 13 shows the results.

Table 13. Scores for energy savings goals and for tax incentives and loan programs, by country

Country	Energy savings goals	Score	Tax incentives and loan programs	Score	Total
France	> 1%	3	Loans and credits	2	5
Germany	> 1%	3	Loans and credits	2	5
Japan	> 1%	3	Loans and credits	2	5
Netherlands	> 1%	3	Loans and credits	2	5
Poland	> 1%	3	Loans and credits	2	5
China	Yes	2	Loans and credits	2	4
India	Yes	2	Loans and credits	2	4
Italy	Yes	2	Loans and credits	2	4
South Korea	Yes	2	Loans and credits	2	4
Spain	> 1%	3	Loans	1	4
Australia	> 1%	3	None	0	3
Canada	GHG	1	Loans and credits	2	3
Russia	Energy intensity	1	Loans and credits	2	3
South Africa	GHG	1	Loans and credits	2	3
Thailand	GHG	1	Loans and credits	2	3
UK	Yes	2	Loans	1	3

Country	Energy savings goals	Score	Tax incentives and loan programs	Score	Total
US	GHG	1	Loans and credits	2	3
Brazil	GHG	1	Loans	1	2
Mexico	GHG	1	Loans	1	2
Taiwan	Energy intensity	1	Loans	1	2
Indonesia	GHG	1	None	0	1
Saudi Arabia	GHG	1	None	0	1
Turkey	GHG	1	None	0	1

"Yes" denotes that a country has an energy savings goal, but the specific goal is either not specified or is less than 1% of total energy consumption. *Sources:* Energy savings goals: UNFCCC 2016; Young et al. 2014. Tax incentives and loan programs: IEA 2016d.

EFFICIENCY OF THERMAL POWER PLANTS (3 POINTS)

The world produces over 67% of all electricity from thermal power plants that use fossil fuels (IEA 2015b). This metric evaluated the overall efficiency of a country's nonnuclear thermal power plants. We took into account both the efficiency of converting heat to electricity in the plant (called *operational efficiency*) and the losses in the electrical-distribution system. The machinery that a plant uses determines its operational efficiency. Supercritical steam generators and combined-cycle power plants have higher operating efficiencies. Countries can achieve a higher power-sector efficiency by employing such technology. We evaluated power generation from combined heat and power (CHP) in the industry section and did not take into account heat generation from thermal power plants in our efficiency calculations.

A number of countries can also improve efficiency by reducing technical and nontechnical losses in the transmission and distribution system. Technical losses occur due to energy dissipated during the various stages of delivering heat and electricity to consumers. Nontechnical losses include pilferage, administrative errors in billing or metering, and equipment errors (World Bank 2009).

We awarded the full 3 points to countries with overall efficiency of 40% or more, 2 points for overall efficiency of 35–40%, and 1 point for overall efficiency of 30–35%. Table 14 shows the data and scores for this metric.

Table 14. Scores for efficiency of thermal power plants

Country	Operational efficiency of thermal power plants (%)	Distribution losses (%)	Overall efficiency of thermal power plants (%)	Score
Japan	44.1	4.4	42.1%	3
Netherlands	43.2	4.4	41.3%	3
Spain	44.6	8.7	40.7%	3
Thailand	42.6	5.7	40.2%	3
Taiwan	41.5	4.0	39.9%	2
US	40.6	6.3	38.1%	2
South Korea	39.2	3.3	37.9%	2
UK	41.1	7.9	37.9%	2
Italy	40.3	7.1	37.4%	2
Mexico	43.9	15.0	37.3%	2
Germany	38.6	3.9	37.1%	2
Turkey	42.7	14.9	36.4%	2
Canada	38.5	7.1	35.8%	2
Brazil	42.7	17.1	35.4%	2
Australia	34.7	5.1	33.0%	1
China	33.7	5.8	31.8%	1
South Africa	34.7	8.8	31.6%	1
Poland	33.8	6.7	31.6%	1
France	33.0	6.7	30.8%	1
Indonesia	32.2	9.1	29.3%	0
Saudi Arabia	32.0	8.8	29.2%	0
India	27.7	17.1	23.0%	0
Russia	25.3	10.0	22.8%	0

Sources: WEC 2016a; World Bank 2016a.

SIZE OF THE ESCO MARKET (2 POINTS)

ESCOs are businesses that manage projects to improve a facility's energy efficiency. ESCOs act as project developers for a range of tasks and assume the technical and performance risks associated with a project. Typically they develop, design, and arrange financing; install and maintain equipment; and measure, monitor, and verify the project's energy savings. These services are bundled into the project owner's budget, and the ESCO is repaid through the dollar savings generated via reduced energy costs. Utilities, private companies, or the government may own an ESCO. The presence and size of the ESCO market in a country reflects the efforts to advance energy efficiency through effective business models and creative financing.

We gave 2 points for an ESCO market size of at least 0.1% of GDP, 1.5 points for market size of at least 0.03% of GDP, 1 point for at least 0.005% of GDP, and 0.5 point for at least 0.0015% of GDP. Table 15 lists the results. The definition of an ESCO varies from country to country. As a result these data may not be directly comparable. We were unable to find data on this metric for a number of countries.

Table 15. Scores for size of the ESCO market relative to GDP

Country	Percentage of GDP	Score
Taiwan	0.1486%	2
Germany	0.1455%	2
France	0.1454%	2
China	0.0869%	1.5
Thailand	0.0387%	1.5
South Korea	0.0384%	1.5
US	0.0382%	1.5
Spain	0.0321%	1.5
Italy	0.0299%	1
Canada	0.0239%	1
UK	0.0119%	1
Japan	0.0075%	1
India	0.0075%	1
Russia	0.0061%	1
Poland	0.0044%	0.5
Mexico	0.0040%	0.5
Australia	0.0025%	0.5
Brazil	0.0010%	0
Indonesia	n/a	0
Netherlands	n/a	0
Saudi Arabia	n/a	0
South Africa	n/a	0
Turkey	n/a	0

Sources: Panev et al. 2014; Bertholdi et al. 2014.

WATER EFFICIENCY POLICY (1 POINT)

Investments aimed at reducing water demand can also reduce energy consumption. Water and energy are linked, intersecting at both the supply side (electricity generation and water/wastewater facilities) and the end-use side (the residential, commercial, industrial, and agriculture sectors). This energy–water nexus is apparent in the massive amounts of water needed to produce and deliver electricity. Coal, nuclear, and solar-thermal electricity

generation are water intensive. Water is needed to create steam and to power turbines; it is also used for cooling and then either lost in the process or discharged back into the environment. Conversely it takes immense amounts of energy to clean and transport water. Pumps, motors, and building equipment in water and wastewater utilities consume a great deal of energy. On the end-use side energy and water are inseparable in our homes, businesses, and industrial facilities, e.g., in the use of hot water. This close relationship means that improvements in water efficiency generally result in energy savings (Young 2013).

Countries can improve their energy efficiency by implementing mandates for water savings and water conservation. Many nations have some type of water efficiency policy. We gave 1 point to countries with national water policies that mandate measures to improve water efficiency or water savings. We did not investigate the enforcement or effectiveness of these policies. Table 16 shows the results.

Table 16. Scores for water efficiency policy

Country	Water policy	Score
Australia	Yes	1
Canada	Yes	1
China	Yes	1
France	Yes	1
India	Yes	1
Indonesia	Yes	1
Italy	Yes	1
Japan	Yes	1
Netherlands	Yes	1
Poland	Yes	1
Saudi Arabia	Yes	1
South Africa	Yes	1
South Korea	Yes	1
Spain	Yes	1
Taiwan	Yes	1
Thailand	Yes	1
Turkey	Yes	1
Brazil	No	0
Germany	No	0
Mexico	No	0
Russia	No	0
UK	No	0
US	No	0

Source: ACEEE country research

DATA AVAILABILITY (1 POINT)

To fully understand their energy efficiency potential, countries must identify key energy-related performance indicators across multiple sectors and track the data over time. Indicators of energy efficiency can be different at the city, state, or country level and for different climate zones and political structures. Countries that track this information will gain insights into energy trends that can help plan policy.

We looked at each of the three end-use energy sectors evaluated in this report and gave 1 point to countries that collect energy data and make them easily accessible online through international centralized sources or through a country-specific source. Countries earned if at least some of their data were available from centralized sources. We awarded 0 points to countries with very little information available through either centralized or country-specific sources. Table 17 displays the scores.

Table 17. Scores for data availability

Country	Data availability	Score
Australia	Widely available	1
Canada	Widely available	1
France	Widely available	1
Germany	Widely available	1
Italy	Widely available	1
Japan	Widely available	1
Mexico	Widely available	1
Netherlands	Widely available	1
Poland	Widely available	1
Russia	Widely available	1
South Korea	Widely available	1
Spain	Widely available	1
UK	Widely available	1
US	Widely available	1
Brazil	Moderately available	0.5
China	Moderately available	0.5
India	Moderately available	0.5
Taiwan	Moderately available	0.5
Turkey	Moderately available	0.5
Indonesia	Scarce	0
Saudi Arabia	Scarce	0
South Africa	Scarce	0
Thailand	Scarce	0

Source: ACEEE country research

NATIONAL EFFORTS BEST PRACTICES

Germany. Germany has emerged as a global leader in advancing energy efficiency with strong national policies and targets. It has gone beyond the European Union's Energy Efficiency Directive to increase energy efficiency from 2008 levels by 20% by 2020. Germany released its National Action Plan on Energy Efficiency (NAPE) in 2014 as part of its energy transition program. The NAPE identifies three areas of focus for the government between 2014 and 2016:

- Increasing energy efficiency in the country's building stock to achieve a reduction of 80% in primary energy demand in buildings, compared to 2008
- Establishing business models for energy efficiency
- Measuring energy savings and collecting data that consumers can use to make decisions about energy use

The country hopes this plan will help achieve a 50% reduction in energy use by 2050 over a 2008 baseline (EIA 2016e).

China. While not among the top scorers in the national efforts section, China has nevertheless taken important steps toward reducing energy consumption and GHG emissions. This year China unveiled its 13th 5-year plan to address economic and social development through 2020. By 2020 the country aims to have reduced energy intensity by 15% from 2015 levels, in addition to capping energy consumption at 4.3 billion tonnes of coal equivalent for the 5-year period. This plan follows China's recent submission of its intended nationally determined contributions (INDCs) proposal to the UNFCCC. According to the INDCs, by 2030 China aims to have reduced its GHG emissions by 60–65% from 2005 levels.

Buildings

Buildings are estimated to use 32% of the energy consumed worldwide (IEA 2016a). In this section countries could earn up to 25 points across 8 metrics for energy efficiency policies and programs targeted at residential and commercial buildings. We focused on a number of best-practice policies that have the largest potential for energy savings in buildings, such as building energy codes and appliance/equipment standards. Codes and standards regulate product efficiency and energy used in buildings and have been proven to save both energy and consumer costs over the last few decades (IEA 2013). We also compared policies that encourage or require energy efficiency retrofits to existing buildings, and policies that require labeling and disclosure of energy-use information for both buildings and appliances. Finally, we evaluated the overall energy intensity of residential and commercial buildings across all the countries as an indicator of current building energy performance.

Germany took first place in the buildings section with a total score of 19.5 points out of 25. Following closely behind were the United States, China, and France. Germany excelled in the building codes and retrofit categories, earning the top score for both metrics. The German government has also implemented mandatory building- and appliance-labeling programs. The United States earned the most points for its appliance standards. In general building labeling and performance standards for appliances and equipment seemed to be standard practices in our evaluated countries, although the comprehensiveness of the building-labeling programs and the number of appliances covered by standards varied by country.

China's high ranking in the buildings section reflects the comprehensive policies the country has implemented to address its buildings-related energy use. Based on feedback we received on our *2014 Scorecard*, our methodology for 2016 evaluated nations more on their buildings-related policies than on performance metrics. China got credit for its comprehensive appliance standards and labeling as well as its building codes for both residential dwellings and commercial facilities. Table 18 lists the countries' total scores in the buildings section and scores on each metric.

Table 18. Scores for buildings by country

Country	Total score	Appliance and equipment standards	Appliance and equipment labeling	Residential building codes	Commercial building codes	Building retrofit policies	Building labeling	Energy intensity in residential buildings	Energy intensity in commercial buildings
Max. score	**25**	**5**	**2**	**4**	**4**	**4**	**2**	**2**	**2**
Germany	19.5	2	2	4	4	4	2	0.5	1
US	18.5	5	1	3.5	3.5	3	0.5	1	1
China	18	5	2	3.5	3	1	1	1	1.5
France	18	2	2	3	3	4	2	0.5	1.5
Canada	17.5	5	1	3.5	3.5	3	0.5	0.5	0.5
Spain	17.5	2	2	3	3	3	1	1.5	2
Italy	17	2	2	3	3	3	2	0.5	1.5
UK	16	2	2	3	3	2	2	0.5	1.5
Australia	15.5	1	1.5	4	4	2	1	0.5	1.5
Netherlands	15	2	2	3	2.5	3	1	0.5	1
Poland	15	2	2	2.5	2.5	3	2	0.5	0.5
Turkey	15	2	2	2.5	2.5	3	2	0.5	0.5
South Korea	14.5	3	2	3.5	3.5	2	0	0.5	0
Japan	13	2	1.5	3.5	2	2	0	1	1
Taiwan	13	1	1.5	2.5	2.5	3	0	1	1.5
Mexico	11	3	1	0	3	0	0	2	2
South Africa	11	0	1	4	4	0	0	0.5	1.5
India	7.5	0	1	1	2.5	0	1	1	1
Brazil	6.5	1	1.5	0	0	0	0	2	2
Russia	6	0	1.5	1.5	1.5	0	1	0	0.5
Indonesia	5.5	0	1	0	2	0	0	1	1.5
Saudi Arabia	5	0	1.5	1.5	1.5	0	0	0.5	0
Thailand	5	0	0.5	0	2.5	1	0	1	0

New in this section

We reallocated points for policy and performance metrics, reducing the weight assigned to building energy intensities by 4 points. As a result building codes and building retrofit policies received 2 more points each. We have also refined our methodology for building codes and building energy intensities given the difficulties inherent in comparing these metrics across countries.

RESIDENTIAL AND COMMERCIAL BUILDING CODES (4 POINTS EACH)

Stringency

We based scores for residential and commercial building codes on the presence of national mandatory building energy codes and the technical areas they cover. We looked at whether codes covered the following technical areas:

Building Shell

- *Insulation in walls and ceiling.* Does the code require levels of insulation for building shell components that are relevant to the climate?
- *U-factors and shading/solar heat gain coefficient for windows.* Does the code require low maximum U-factors and shading/solar heat gain coefficients for windows and doors? The U-factor measures the rate of heat transfer through a window and rates how well the window insulates. The solar heat gain coefficient measures the fraction of solar energy transmitted, indicating how well the window blocks heat from solar radiation.
- *Air sealing.* Does the code require buildings to meet certain air tightness levels, verified by testing?

Technical Components

- *Efficient lighting.* Does the code include minimum standards for lighting efficiency, lamps, and/or lighting controls?
- *Efficient heating, ventilating, and air-conditioning systems.* Does the code require a level of efficiency for heating, ventilating, and cooling systems? Does the code have design requirements for these systems?
- *Efficient water heating.* Does the code require minimum efficiency levels for hot-water systems?

While we recognize the importance of scoring each country on the stringency of the above requirements, we did not have the capacity to do so this year.

Implementation

We also ranked countries on their efforts to implement and enforce energy codes. While a code may be developed and adopted at the national level it is usually implemented and enforced at the local or regional level. A national government may take a number of actions to aid successful implementation at the local level. These include the development of tools to help localities assess compliance with the energy code, such as compliance-checking software or rating tools, training and/or education materials, incentives for code compliance, and studies to evaluate and measure the performance of building energy codes (IPEEC 2015b). Countries received points if we found any evidence that the national

government was making even small efforts to aid in code implementation at the local level through any of the above mechanisms. We used information from the International Partnership for Energy Efficiency Cooperation (IPEEC 2015b) and in-country experts to rate countries on compliance.

Within each buildings sector (residential and commercial), we awarded 1 point to countries with mandatory national building codes. Countries with codes that cover the majority of their populations (often called mixed codes) received 0.5 point; those with voluntary or no codes received no points. We then allocated 2 points based on the building shell and technical requirements (detailed above) included in the code. If countries met five or six technical requirements, they earned the full 2 points. Countries that satisfied at least three or four technical requirements earned 1.5 points, those meeting two technical requirements earned 1 point, and those meeting one technical requirement earned 0.5 point. Last, we awarded up to 1 point for code implementation efforts. Tables 19 and 20 show scores in the two sectors.

Table 19. Scores for residential building codes

Country	Code stringency	Code stringency score	Score for building shell and technical requirements	Code compliance score	Combined score
Australia	Mandatory	1	2	1	4
Germany	Mandatory	1	2	1	4
South Africa	Mandatory	1	2	1	4
Canada	Mixed	0.5	2	1	3.5
China	Mixed	0.5	2	1	3.5
Japan	Mixed	0.5	2	1	3.5
South Korea	Mandatory	1	1.5	1	3.5
US	Mixed	0.5	2	1	3.5
France	Mandatory	1	2	0	3
Italy	Mandatory	1	2	0	3
Netherlands	Mandatory	1	2	0	3
Spain	Mandatory	1	2	0	3
UK	Mandatory	1	2	0	3
Poland	Mandatory	1	1.5	0	2.5
Taiwan	Mandatory	1	1.5	0	2.5
Turkey*	Mandatory	1	0.5	1	2.5
Russia	Mandatory	1	0.5	0	1.5
Saudi Arabia	Mandatory	1	0.5	0	1.5
India	Voluntary	0	0	1	1
Indonesia	Voluntary	0	0	0	0

Country	Code stringency	Code stringency score	Score for building shell and technical requirements	Code compliance score	Combined score
Brazil	None	0	0	0	0
Mexico	None	0	0	0	0
Thailand	n/a	0	0	0	0

* Thermal regulation only. *Sources:* IPEEC 2015b; Young 2014; IPEEC 2016a–k; Evans, Shui, and Delgado 2009; ACEEE Taiwan data request.

Table 20. Scores for commercial building codes

Country	Code stringency	Code stringency score	Score for building shell and technical requirements	Code compliance score	Combined score
Australia	Mandatory	1	2	1	4
Germany	Mandatory	1	2	1	4
South Africa	Mandatory	1	2	1	4
Canada	Mixed	0.5	2	1	3.5
South Korea	Mandatory	1	1.5	1	3.5
US	Mixed	0.5	2	1	3.5
China	Mixed	0.5	1.5	1	3
France	Mandatory	1	2	0	3
Italy	Mandatory	1	2	0	3
Mexico	Mixed	0.5	1.5	1	3
Spain	Mandatory	1	2	0	3
UK	Mandatory	1	2	0	3
India	Voluntary	0	1.5	1	2.5
Netherlands	Mandatory	1	1.5	0	2.5
Poland	Mandatory	1	1.5	0	2.5
Taiwan	Mandatory	1	1.5	0	2.5
Thailand	Mandatory	1	1.5	0	2.5
Turkey*	Mandatory	1	0.5	1	2.5
Indonesia	Mixed	0.5	1.5	0	2
Japan	Mandatory	1	0	1	2
Russia	Mandatory	1	0.5	0	1.5
Saudi Arabia	Mandatory	1	0.5	0	1.5
Brazil	None	0	0	0	0

* Thermal regulation only. *Sources:* IPEEC 2015b; Young 2014; IPEEC 2016a–k; Evans, Shui, and Delgado 2009; ACEEE Taiwan data request.

APPLIANCE AND EQUIPMENT STANDARDS (5 POINTS)

Policies requiring minimum energy performance standards (MEPSs) for appliances and equipment were eligible for up to 5 points. This metric does not measure the stringency of these standards, the percentage of energy consumption covered by the standards, or compliance with the standards, all of which are important factors impacting the energy efficiency of appliances and equipment and can be influenced by other, nonenergy factors.

We scored the countries based on the number of appliance and equipment types covered by mandatory energy performance standards. Table 21 shows the point breakdown, and table 22 shows related scores.

Table 21. Point allocation for appliance and equipment standards

Number of appliance and equipment standards	Points
50	5
40	4
30	3
20	2
10	1

APPLIANCE AND EQUIPMENT LABELING (2 POINTS)

Labeling programs help consumers make purchasing decisions by disclosing how much energy an appliance or a particular piece of equipment uses compared to similar products of the same type. Labels typically display this comparative information using either a categorical rating or a continuous scale. Categorical labels give the models distinct rankings or scores based on energy use or efficiency, while continuous scales mark the high and low ends of energy use or efficiency among models and place each model in the appropriate place along the continuum. An example of a categorical labeling system is the European Union's scheme, which awards a letter grade to a product. The EnergyGuide program in the United States is a continuous-scale labeling program (see figure 4).

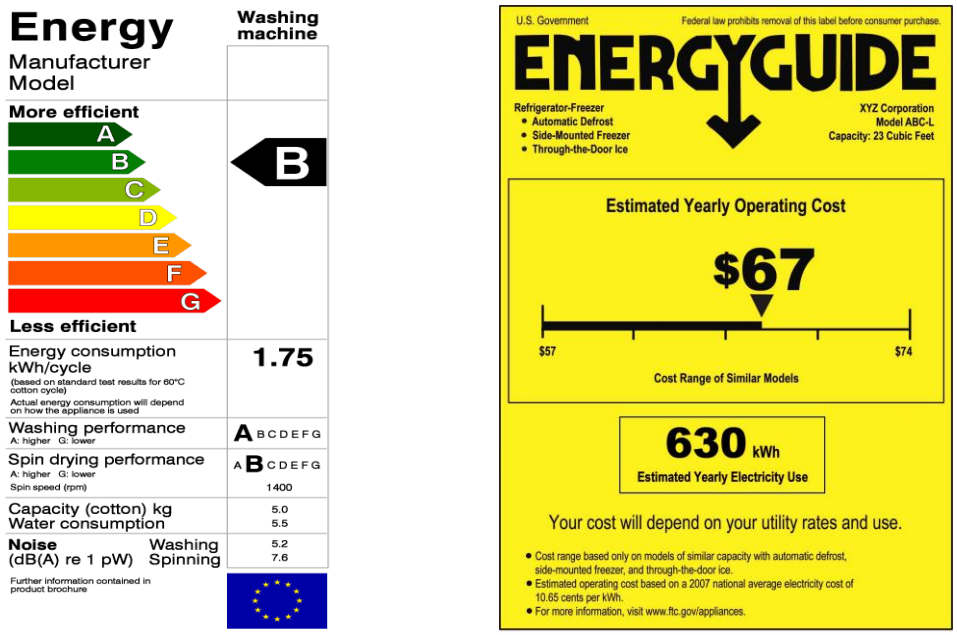


Figure 4. Categorical (left) and continuous (right) styles for appliance labeling

Only countries with mandatory appliance and equipment labeling could earn up to 2 points. We gave 1 point for categorical labels and 0.5 point for continuous labels. We awarded another point to countries with labels covering at least 15 appliance groups and 0.5 point to those with labels covering at least 5 appliance groups. Table 22 shows scores on this metric.

Table 22. Scores for standards (left) and labeling (right) of appliances and equipment

Country	Number of appliance categories with minimum energy performance standards (MEPS)	Score
US	60	5
China	55	5
Canada	53	5
South Korea	32	3
Mexico	30	3
Turkey	28	2
Japan	26	2
France	21	2
Germany	21	2
Italy	21	2
Netherlands	21	2
Poland	21	2
Spain	21	2
UK	21	2
Australia	18	1
Taiwan	18	1
Brazil	12	1
India	7	0
South Africa	6	0
Thailand	2	0
Indonesia	1	0
Russia	1	0
Saudi Arabia	1	0

Country	Mandatory or voluntary	Categorical or continuous	Appliance groups	Score
China	Mandatory	Categorical	28	2
France	Mandatory	Categorical	15	2
Germany	Mandatory	Categorical	15	2
Italy	Mandatory	Categorical	15	2
Netherlands	Mandatory	Categorical	15	2
Poland	Mandatory	Categorical	15	2
South Korea	Mandatory	Categorical	22	2
Spain	Mandatory	Categorical	15	2
Turkey	Mandatory	Categorical	22	2
UK	Mandatory	Categorical	15	2
Australia	Mandatory	Categorical	11	1.5
Brazil	Mandatory	Categorical	14	1.5
Japan	Mandatory	Categorical	6	1.5
Russia	Mandatory	Continuous	20	1.5
Saudi Arabia	Mandatory	Categorical	5	1.5
Taiwan	Mandatory	Categorical	9	1.5
Canada	Mandatory	Continuous	12	1
India	Mandatory	Categorical	4	1
Indonesia	Mandatory	Categorical	2	1
Mexico	Mandatory	Continuous	13	1
South Africa	Mandatory	Categorical	3	1
US	Mandatory	Continuous	8	1
Thailand	Voluntary	Categorical	13	0.5

Source: CLASP 2016

BUILDING RETROFIT POLICIES (4 POINTS)

For this edition of the *International Scorecard* we increased the weight given to this metric by 2 points. Globally the existing building stock tends to be old and inefficient, providing a tremendous opportunity for energy savings. Countries can more fully capture building energy savings by adopting policies to require improved efficiency during a building redesign or retrofit. While building energy codes usually apply only to new construction, some countries extend code requirements to major building renovations. All European countries in this edition of the *Scorecard* have mandatory building energy codes for existing buildings, including a MEPS (IEA 2013).

For this metric we awarded 4 points to countries whose codes either require energy-efficient upgrades within a specific time frame; require the improvement of overall building energy performance when any building extension, addition, or conversion is done; or prohibit renting out or selling a building with poor energy performance (BPIE 2015). We awarded 3 points to countries with mandatory national building energy codes that apply to renovation projects undertaken for both commercial and residential buildings, or state or provincial codes that apply to two-thirds of the population. Countries earned 2 points if they have mandatory state or provincial codes that cover either residential or commercial buildings, or if they have mandatory national codes that cover either residential or commercial buildings. We gave 1 point to countries with no code but with federal incentives in place to encourage retrofits.

Table 23 summarizes the presence or absence of retrofit policies in the evaluated countries along with their corresponding scores.

Table 23. Scores for building retrofit policies

Country	Building retrofit policies	Score
France	Mandatory renovation code; upgrades required within a specific time frame	4
Germany	Mandatory renovation code; upgrades required within a specific time frame	4
Canada	Provincial renovation codes covering majority of population	3
Italy	Mandatory renovation code	3
Netherlands	Mandatory renovation code	3
Poland	Mandatory renovation code	3
Spain	Mandatory renovation code	3
Taiwan	Mandatory renovation code	3
Turkey	Mandatory renovation code	3
US	State renovation codes covering majority of population	3
Australia	State renovation codes covering small portion of population	2

Country	Building retrofit policies	Score
Japan	Mandatory renovation code; submission of energy efficiency plans	2
South Korea	Mandatory renovation code, residential only	2
UK	Mandatory renovation code, commercial only	2
China	Incentives	1
Thailand	Incentives	1
Brazil	Voluntary	0
India	None	0
Indonesia	None	0
Mexico	None	0
Russia	None	0
Saudi Arabia	None	0
South Africa	None	0

Sources: IEA 2016d; DOE 2014 (China); BPIE 2015 (France, Germany, UK); IPEEC 2016k (Spain); Republic of China 2016 (Taiwan); CCAP 2013 (Thailand); IPEEC 2016i (Turkey).

BUILDING LABELING (2 POINTS)

We based scores for the next buildings-related metric on the presence of a mandatory building labeling or rating system and the mandatory disclosure of energy use. A building label creates transparency regarding the energy costs associated with a building, similar to the transparency provided by a miles-per-gallon rating for a vehicle. Disclosure of a building's energy use can assist potential owners or tenants in recognizing the benefits of energy efficiency at the time of a purchase or lease.

We gave the full 2 points to countries with disclosure and labeling requirements applicable to all buildings (new and existing, commercial and residential). We gave 1 point to countries with mandatory building rating policies that apply only to new buildings or only to a subset of buildings (e.g., commercial but not residential). Table 24 lists the scores on this metric.

Table 24. Scores for building labeling programs by country

Country	Building rating	Buildings covered	Score
France	Mandatory	All	2
Germany	Mandatory	All	2
Italy	Mandatory	All	2
Poland	Mandatory	All	2
Turkey	Mandatory	All	2
UK	Mandatory	All	2

Country	Building rating	Buildings covered	Score
Australia	Mandatory	Some	1
China	Mandatory	Some	1
India	Mandatory	Some	1
Netherlands	Mandatory	Some	1
Russia	Mandatory	Some	1
Spain	Mandatory	Some	1
Canada*	Voluntary	All	0.5
US*	Voluntary	–	0.5
Japan	Voluntary	All	0
Brazil	Voluntary	–	0
Mexico	Voluntary	–	0
South Korea	Voluntary	–	0
Taiwan	Voluntary	–	0
Thailand	Voluntary	–	0
Indonesia	None	–	0
Saudi Arabia	None	–	0
South Africa	None	–	0

* We awarded partial points for voluntary programs in Canada and the United States because both of these programs have been used on a number of buildings to date. *Sources:* IMT 2016; IPEEC 2016l.

ENERGY INTENSITY OF RESIDENTIAL AND COMMERCIAL BUILDINGS (2 POINTS EACH)

A variety of factors affect energy use in buildings including population, building floor area, and the level of economic activity (IPEEC 2015a). Energy efficiency policies and programs for buildings can alter the impact of increases in building floor space, population, and GDP on energy use. To evaluate the energy intensity of buildings in each country we relied on four metrics. Each metric has benefits and limitations.

Residential

We compare the energy intensity of residential buildings between countries using two metrics to evaluate energy use based on services provided. Looking at residential energy use per capita allows us to see building energy use across countries relative to the number of people served. Energy use per capita depends on building services and size as well as the efficiency of the building's structure, equipment, and appliances. In developed economies energy use per capita has generally stayed the same or grown very slowly. In developing countries energy use per capita continues to grow as people gain access to more building services and amenities (IPEEC 2015a).

Looking at residential energy use per floor area reveals how buildings are performing compared to the amount of building space provided. As buildings become more efficient

through improved equipment, appliances, and tighter building envelopes, less energy is required to provide services to the same amount of space. One caveat on this metric is that larger home sizes can increase energy use. There are significant differences between countries in the average floor area of homes. The average house size in the United States, Canada, and Australia is nearly double that of many other countries, making countries with large homes look more efficient than those with smaller living spaces. While some types of energy use in the home (such as for heating and cooling or lighting) grow with increasing size, other uses (such as cooking, refrigeration, or water heating) generally remain the same (IPEEC 2015a).

Because no single metric is perfect, we include both energy use per capita and energy use per floor area in this report to represent energy intensity in residential buildings.

Commercial

We compare the energy intensity of commercial buildings between countries using two metrics to evaluate energy use based on services provided. Looking at commercial energy use per dollar of service-sector GDP lets us isolate energy-use trends from differences in GDP. Looking at commercial energy use by building size reveals building energy trends independent of floor area.

Many countries do not consistently track floor area, particularly in the commercial sector, so we were forced to use data from varying years to calculate our energy intensity estimates. Figures on residential floor area and/or residential floor area per capita are tracked and available for a number of the major economies because these data are included in census data collection. Note that we used final energy consumption of residential buildings, as primary energy use by sector was not available for each country.

Additionally, adjusting building energy use for differences in climate between countries can be challenging. First, standards and expectations for indoor temperatures vary between countries. Not all buildings are heated and cooled to the same temperatures (or heated and cooled at all). Second, space heating and cooling account for varying portions of overall building energy use among different countries. In some developed countries such as the United States, space-conditioning accounts for less than half of overall residential energy consumption, while end uses including lighting, appliances, and miscellaneous loads are increasing (IEA 2013). In other countries such as Brazil and India, many households do not have heating and cooling systems (Young et al. 2014). In commercial buildings space-conditioning loads generally account for a lower percentage of overall energy use than in the residential sector.

We adjusted the share of residential-building energy intensity used for heating and cooling to reflect variations in climate between countries. Appendix A details the process we used to normalize the portion of energy used for heating and cooling in residential buildings. We followed the same methodology for both residential-intensity metrics: energy use per floor area and energy use per capita. The adjustment serves the sole purpose of allowing a fairer comparison between countries with different heating and cooling needs. The results should not be interpreted as absolute values. (See scores for relative intensities in table 27.)

Countries could receive up to 4 points on this metric. Table 25 and table 26 show the point allocation for this metric for residential and commercial buildings, respectively. Table 27 and table 28 list the energy intensity data and scores for the residential and commercial sectors, respectively.

Table 25. Scoring criteria for residential energy intensity

Final energy use per floor area in million British thermal units/square meter (MMBtus/m²)	Score	Final energy use per capita (MMBtus/capita)	Score
≤ 0.35	1	≤ 10	1
≤ 0.6	0.5	≤ 19	0.5
> 0.6	0	> 19	0

Table 26. Scoring criteria for commercial energy intensity

Final energy use per floor area (MMBtus/m²)	Score	Final energy use per GDP (MMBtus/$GDP)	Score
≤ 0.8	1	≤ 450	1
≤ 2.0	0.5	≤ 750	0.5
> 2.0	0	> 750	0

Table 27. Scores for energy intensity in residential buildings

Country	MMBtus/m² of residential space	Score	MMBtus/capita	Score	Combined score
Brazil	0.29	1	4.55	1	2
Mexico	0.16	1	5.83	1	2
Spain	0.31	1	13.76	0.5	1.5
China	0.36	0.5	10.48	0.5	1
India	0.62	0	5.47	1	1
Indonesia	0.64	0	8.41	1	1
Japan	0.36	0.5	14.93	0.5	1
Taiwan	0.37	0.5	14.33	0.5	1
Thailand	1.19	0	6.95	1	1
US	0.34	1	24.50	0	1
Australia	0.40	0.5	23.43	0	0.5
Canada	0.47	0.5	28.49	0	0.5
France	0.52	0.5	22.00	0	0.5
Germany	0.40	0.5	20.58	0	0.5

Country	MMBtus/m² of residential space	Score	MMBtus/capita	Score	Combined score
Italy	0.50	0.5	21.55	0	0.5
Netherlands	0.39	0.5	19.15	0	0.5
Poland	0.85	0	16.50	0.5	0.5
Saudi Arabia	n/a	0	10.99	0.5	0.5
South Africa	0.69	0	12.82	0.5	0.5
South Korea	0.72	0	14.48	0.5	0.5
Turkey	0.63	0	10.45	0.5	0.5
UK	0.42	0.5	19.05	0	0.5
Russia	0.83	0	19.51	0	0

Sources: Energy consumption in buildings: IEA 2016e. Floor space: IPEEC 2015a; BPIE 2011 (Netherlands, Poland, Spain); ACEEE estimates based on Solidiance 2013 (Thailand); UNECE 2004 (Thailand).

Table 28. Scores for energy intensity in commercial buildings

Country	MMBtus/m² of commercial space	Score	MMBtus/$GDP	Score	Combined score
Brazil	0.58	1	272.45	1	2
Mexico	0.13	1	207.40	1	2
Spain	0.77	1	397.06	1	2
Australia	0.83	0.5	261.11	1	1.5
China	0.24	1	611.90	0.5	1.5
France	1.29	0.5	424.69	1	1.5
Indonesia	0.24	1	525.28	0.5	1.5
Italy	0.99	0.5	411.85	1	1.5
South Africa	0.70	1	631.53	0.5	1.5
Taiwan	0.61	1	488.35	0.5	1.5
UK	0.89	0.5	310.98	1	1.5
Germany	1.27	0.5	537.40	0.5	1
India	0.26	1	814.37	0	1
Japan	1.89	0.5	581.60	0.5	1
Netherlands	1.65	0.5	549.08	0.5	1
US	1.38	0.5	619.16	0.5	1
Canada	1.92	0.5	788.00	0	0.5
Poland	1.77	0.5	1,023.72	0	0.5
Russia	1.70	0.5	1,193.90	0	0.5
Turkey	1.39	0.5	832.77	0	0.5
Saudi Arabia	n/a	0	974.78	0	0

Country	MMBtus/m² of commercial space	Score	MMBtus/$GDP	Score	Combined score
South Korea	3.33	0	1,143.87	0	0
Thailand	2.45	0	1,282.40	0	0

Sources: Energy consumption in buildings: IEA 2016e. Floor space: IPEEC 2015a; BPIE 2011 (Netherlands, Poland, Spain); ACEEE estimates based on Solidiance 2013 (Thailand); UNECE 2004 (Thailand).

BUILDINGS BEST PRACTICES

Germany. Germany adopted the National Energy Saving Ordinance for buildings in 2002, setting energy performance requirements for new buildings and existing ones undergoing major renovations. The ordinance also outlines guidelines for building labels and requires that labels contain enough information to allow for a reasonable comparison of one building's energy performance with another's (IEA 2016d). Recent updates to Germany's energy efficiency strategy for buildings have focused largely on the deep retrofit of buildings constructed between 1950 and 1980, some of the most inefficient buildings in the country (BPIE 2014). The KfW Energy-Efficient Construction Programme, which has been in place since 2006, provides financial support for new buildings that meet an applicable standard and is the largest financial program available for sustainable buildings in Europe (BPIE 2014). The KfW program is also the largest building retrofit program of its kind. It supports every building owner who undertakes a more ambitious project than the code requires, whether new construction or a retrofit, residential or commercial/industrial.

United States. Like Germany, the United States is a longtime leader in energy efficiency policies for buildings. While US residential and commercial building codes are implemented at the state level, they are still some of the most aggressive in the world and include strict requirements for building envelope, heating and cooling, and lighting. US building energy codes are expected to save 46 quadrillion British thermal units (quads) of energy cumulatively by 2040. The United States is also far and away the leader in appliance and equipment standards, with as many as 60 different standards on record. Products covered by these standards represent about 90% of home energy use and 60% of commercial-building use in the United States. The 40 standards introduced during the Obama administration alone will save 43.8 quads of energy by 2030, according to the US Department of Energy (DOE)'s Appliance and Equipment Standards Program.

Industry

The industrial sector is responsible for over half of the total final energy consumed in the world, more than any other end-use sector (EIA 2015b). In the third edition of the *International Scorecard*, we captured energy efficiency policy and performance in industry using a total of 10 metrics, including 3 new policy metrics. The maximum a country could score in this section was 25 points. We evaluated the energy intensity of industry and the presence of policies to improve it, including voluntary agreements to increase industrial efficiency, national mandates for energy managers, energy audits in large facilities, and investment in industry-specific R&D. We scored countries on the share of CHP in their overall electric power sector capacity and the policies implemented to encourage CHP. We also looked at policies to support the integration of energy efficiency into management practices through the use of energy management systems (EnMS) and ISO 50001, and we took into account the presence of MEPSs for motors.[2] Finally, we evaluated countries' overall agricultural energy intensity.

Germany received the top score with 21 points, followed by Japan with 20.5 points. The United Kingdom and Italy tied for third with 19.5 points each. The top-scoring countries generally had lower energy intensities, a high percentage of industrial electricity generated by CHP or comprehensive policies in place to encourage CHP deployment, and voluntary government programs aimed at improving energy efficiency in partnership with businesses.

The policies that countries have adopted to address energy efficiency in the industrial sector vary considerably, and no country received a perfect score in this section. The European countries did a consistently good job across all metrics, and they stand out for their voluntary agreements and mandatory energy audits for facilities. All countries have some room for improvement. Table 29 lists the section total and scores for each country on individual metrics.

[2] Companies use EnMS to establish and integrate policies and procedures for systematically tracking, analyzing, and improving energy efficiency. ISO 50001, the global EnMS standard, specifies requirements for establishing, implementing, maintaining, and improving an EnMS (DOE 2016). The EnMS abbreviation is intended to avoid confusion with an energy management system (EMS), which may refer to computerized controls and supervisory control and data acquisition (SCADA) systems in the United States.

Table 29. Industry sector scores by country

Country	Total score	Energy intensity of industry	Voluntary agreements	Mandate for energy managers	Mandatory energy audits	CHP installed capacity	CHP policy	Motor standards	EnMS policy	R&D investment	Agri. energy intensity
Max. score	**25**	**6**	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
Germany	21	5	3	0	2	1.5	2	2	2	1.5	2
Japan	20.5	5	2	2	2	0	2	2	2	2	1.5
UK	19.5	6	3	0	2	0.5	1	2	2	1.5	1.5
Italy	19.5	5	3	2	2	1.5	1	2	1	0.5	1.5
South Korea	18.5	4	3	0	2	1	1	2	2	2	1.5
France	16.5	5	3	0	2	0	1	2	1	1.5	1
Indonesia	16	6	2	2	2	0	0	0	2	0	2
Netherlands	16	5	2	0	2	2	1	2	1	1	0
Taiwan	16	3	0	2	2	1.5	1	1	2	1.5	2
Spain	15.5	4	3	0	2	0.5	0	2	2	0.5	1.5
China	15	0	3	2	2	1	1	1	2	1	2
US	14.5	3	2	0	0	0.5	2	2	2	2	1
Turkey	14	3	3	2	0	0.5	0	1	2	0.5	2
India	13.5	0	3	2	2	0.5	2	0	2	0	2
Canada	13.5	4	3	0	0	0.5	1	2	2	0.5	0.5
Thailand	13	2	3	2	2	0.5	0	0	2	0	1.5
Mexico	11.5	5	0	0	0	0	1	2	2	0	1.5
Poland	11.5	3	0	0	2	1.5	1	2	1	0	1
Russia	10	1	3	0	0	2	0	0	2	0.5	1.5
Brazil	6	1	0	0	0	0.5	1	1	0	1	1.5
Australia	5.5	2	0	0	0	0.5	0	1	0	1	1
South Africa	5	0	3	0	0	0	1	0	0	0	1
Saudi Arabia	4	1	0	0	0	0	0	1	0	0	2

New in this section

The industry section includes three new metrics this year. We reduced the total points for CHP from 6 to 4 points and split them evenly between a performance indicator and a new policy indicator. We created a new metric that considers policies to support the integration of energy efficiency into management practices through EnMS and ISO 50001. Another new metric considers minimum efficiency standards for electric motors. We discuss these changes in detail below.

ENERGY INTENSITY OF INDUSTRY (6 POINTS)

Countries vary widely in the mix and structure of their industrial sectors. Depending on the size and type of predominant industries, energy consumption will also vary from one economy to another. Additionally, industrial processes can differ across regions, which can significantly affect energy use. For this reason benchmarking the energy intensities of industry subsectors is essential to understanding and optimizing energy use in each subsector. However such information is not tracked consistently across all countries.

For our rankings we measured the energy intensity of industry as a whole using energy consumed (measured in thousands of British thermal units, or kBtus) per dollar of industrial GDP.[3] First, we calculated raw energy intensities using overall industrial energy consumption (IEA 2016e) and overall industrial GDP (World Bank 2016d). Then, to adjust for the differences in the mix of industries we used a weighting factor that assumes that the pattern of intensities among the countries' industry subsectors will be relatively similar. To calculate this weighting factor, we assumed that the energy intensities of US industries are indicative of other countries' industry intensities (EIA 2015a; EIA 2013). A complete description of the steps is available in Appendix A.

To facilitate evaluation in a more meaningful way and to better inform energy policy, comparisons must be made between similar industry subsectors across the world. Countries should report both energy consumption data and value added by each type of industry to better inform energy efficiency policies. Additionally, international harmonization on the definitions of industrial subsectors would help ensure fairer comparisons.[4]

---

[3] Industries are grouped into the following categories by our primary data source for this metric, the International Energy Agency: iron and steel, chemical and petrochemical, nonferrous metals, nonmetallic minerals, transport equipment, machinery, mining and quarrying, food and tobacco, paper, pulp and printing, wood and wood products, textile and leather, and nonspecified (industry). These data do not include energy consumption in agriculture.

[4] In some cases concerns with the representative nature of country data, related to final energy consumption by industry grouping, prevented fair comparison. For example, 98% of final energy consumption in Saudi Arabia is reported as nonspecified, which distorts results. To address this problem we moved half of Saudi Arabia's nonspecified energy consumption to the mining and quarrying category. We made no adjustments for other countries, but this issue warrants further investigation.

Countries with the lowest weighted energy consumption per dollar of industrial GDP (i.e., less than 2 kBtus per dollar of industrial GDP) received 6 points. Table 30 shows the breakdown of points, and table 31 lists the results by country.

Table 30. Point allocation for energy intensity of industry

kBtus per dollar of industrial GDP	Points
< 2	6
≤ 2.5	5
≤ 3.5	4
≤ 4.5	3
≤ 6.5	2
≤ 7.5	1
> 7.5	0

Table 31. Scores for energy intensity of industrial sector

Country	Relative intensity factor	kBtus/$	Joules/$	Score
UK	0.73	1.3	1,322	6
Indonesia	0.46	1.7	1,764	6
Mexico	0.64	2.0	2,136	5
Germany	1.11	2.1	2,240	5
Italy	1.06	2.2	2,316	5
Netherlands	0.86	2.2	2,345	5
France	1.12	2.2	2,359	5
Japan	0.90	2.3	2,393	5
Spain	1.22	3.0	3,156	4
Canada	1.72	3.1	3,308	4
South Korea	0.86	3.3	3,440	4
US	1.22	3.7	3,878	3
Turkey	0.92	4.1	4,307	3
Taiwan	0.82	4.2	4,455	3
Poland	1.36	4.4	4,671	3
Australia	1.95	4.7	4,928	2
Thailand	0.84	6.1	6,412	2
Brazil	1.20	6.7	7,105	1
Saudi Arabia	1.70	6.9	7,280	1
Russia	1.15	7.5	7,901	1

Country	Relative intensity factor	kBtus/$	Joules/$	Score
India	0.62	7.7	8,149	0
China	1.10	10.1	10,670	0
South Africa	1.06	10.2	10,723	0

Sources: IEA 2016f; World Bank 2016, 2016d.

VOLUNTARY AGREEMENTS WITH MANUFACTURERS (3 POINTS)

We based the scoring for this metric on the presence of a national government program for entering into voluntary agreements with businesses in the manufacturing sector to improve energy efficiency.

We gave the highest score of 3 points for the presence of a program that establishes voluntary agreements with manufacturers for reducing consumption and offers incentives or other financial support for achievements and/or participation. Countries with agreements that do not offer incentives received 2 points. We also recognized countries with mandatory agreements, such as China and Japan, even though we did not award additional points for legally binding programs. Table 32 shows these data and scores by country.

MANDATE FOR ENERGY MANAGERS (2 POINTS)

We scored this metric according to whether or not a country had a national law or regulation requiring large industrial facilities to employ an energy management expert on site. A dedicated onsite energy manager can improve processes, identify waste, and maximize the efficient use of energy resources. However, in spite of the economic benefits of reduced energy waste and the increased economic productivity that can come from having an onsite expert, only a few of the countries analyzed had such a requirement.

Countries that had a plant energy manager mandate received 2 points. Table 32 displays the results.

MANDATORY ENERGY AUDITS (2 POINTS)

Periodic energy audits can help businesses identify opportunities to improve energy efficiency, benchmark improvements, and identify negative trends.

We awarded 2 points to a country if it had a national law or regulation requiring periodic energy audits of large industrial facilities. Table 32 lists the findings for this indicator.

Table 32. Scores for voluntary agreements with manufacturers, mandates for energy managers, and mandatory energy audits

Country	Voluntary agreements with manufacturers	Score	Mandate for energy managers	Score	Mandatory energy audits	Score	Combined score
China	Agreements and incentives	3	Yes	2	Yes	2	7
India	Agreements and incentives	3	Yes	2	Yes	2	7
Italy	Agreements and incentives	3	Yes	2	Yes	2	7
Thailand	Agreements and incentives	3	Yes	2	Yes	2	7
Indonesia	Agreements	2	Yes	2	Yes	2	6
Japan	Agreements	2	Yes	2	Yes	2	6
France	Agreements and incentives	3	No	0	Yes	2	5
Germany	Agreements and incentives	3	No	0	Yes	2	5
South Korea	Agreements and incentives	3	No	0	Yes	2	5
Spain	Agreements and incentives	3	No	0	Yes	2	5
Turkey	Agreements and incentives	3	Yes	2	No	0	5
UK	Agreements and incentives	3	No	0	Yes	2	5
Netherlands	Agreements	2	No	0	Yes	2	4
Taiwan	None	0	Yes	2	Yes	2	4
Canada	Agreements and incentives	3	No	0	No	0	3
Russia	Agreements and incentives	3	No	0	No	0	3
South Africa	Agreements and incentives	3	No	0	No	0	3
Poland	None	0	No	0	Yes	2	2
US	Agreements	2	No	0	No	0	2
Australia	None	0	No	0	No	0	0
Brazil	None	0	No	0	No	0	0
Mexico	None	0	No	0	No	0	0
Saudi Arabia	None	0	No	0	No	0	0

Sources: IEA 2016d; IIP 2016c; ABB 2013a–h; IIP 2016c (Thailand); SANEDI 2014 (South Africa).

POLICY TO ENCOURAGE ENERGY MANAGEMENT (2 POINTS)

One way national governments can consolidate energy efficiency policies for industries is by adopting energy management systems (EnMS). The purpose of an EnMS standard is to provide guidance for industrial and commercial facilities to integrate energy efficiency into their management practices, including fine-tuning production processes and improving the energy efficiency of industrial systems (McKane et al. 2009). Some policies may also require companies to take into account relevant national or international standards. In 2011 the International Organization for Standardization (ISO) adopted the ISO 50001 energy management system standard, which provides a common framework for industrial facilities, commercial facilities, or entire organizations (ISO 2016). Energy planning, management, implementation, training, and auditing are all vital to the standard. More than 6,700 sites worldwide had achieved ISO 50001 certification as of 2014 (ISO 2014). The growth of ISO 50001 is expected to accelerate as an increasing number of companies integrate ISO 50001 into their corporate sustainability strategies and supplier requirements.

We awarded each country 2 points if it had national policies to encourage EnMS that reference and encourage ISO 50001 certification. Countries that have not yet embraced the ISO 50001 standard but have an energy management policy in place received 1 point. Table 33 lists the number of facilities certified ISO 50001 in 2014, along with the countries' scores. However the number of certified facilities did not impact a country's score.

Table 33. Scores for policies to encourage EnMS

Country	Energy management policy	Policy reference to ISO 50001	Number of ISO 50001–certified firms	Score
Canada	Yes	Yes	11	2
China	Yes	Yes	65	2
Germany	Yes	Yes	3,402	2
India	Yes	Yes	271	2
Indonesia	Yes	Yes	24	2
Japan	Yes	Yes	59	2
Mexico	Yes	Yes	16	2
Russia	Yes	Yes	81	2
South Korea	Yes	Yes	102	2
Spain	Yes	Yes	310	2
Taiwan	Yes	Yes	176	2
Thailand	Yes	Yes	168	2
Turkey	Yes	Yes	76	2
UK	Yes	Yes	376	2
US	Yes	Yes	58	2
France	Yes	No	270	1

Country	Energy management policy	Policy reference to ISO 50001	Number of ISO 50001–certified firms	Score
Italy	Yes	No	294	1
Netherlands	Yes	No	24	1
Poland	Yes	No	38	1
Australia	No	No	20	0
Brazil	n/a	n/a	23	0
Saudi Arabia	No	No	3	0
South Africa	No	No	4	0

Sources: IIP 2016c; ISO 2014.

CHP INSTALLED CAPACITY (2 POINTS)

CHP systems generate electricity and useful thermal energy in a single integrated system. The use of CHP systems is much more efficient than the separate generation of thermal energy and electricity because heat that is normally wasted in conventional power generation is recovered to meet thermal demands.

For this metric we awarded points according to the share of electrical CHP capacity in the country's overall electric power sector. Information on installed capacity is more readily available for a greater number of countries than other CHP data that may be more indicative of a country's use of CHP. For example, evaluating the share of electricity actually produced by CHP systems may be a better measure of whether a country utilizes CHP as a key technology. Further, as a measure of industrial efficiency it would be most useful to look at the share of industrial CHP in industrial electricity consumption. However, due to limited data availability, we focused instead on the overall installed capacity of CHP. Any indicator is highly subject to the technical potential for CHP in a given country. It is also important to note that most CHP is installed in the industrial sector, but some countries show greater use of CHP in commercial, institutional, and municipal applications.

We gave the full 2 points to countries where CHP makes up at least 40% of the installed power capacity. Countries that generate at least 15% of installed power capacity from CHP earned 1.5 points, those with at least 10% from CHP earned 1 point, and those with at least 5% from CHP earned 0.5 point. Table 34 lists the results by country.

Table 34. Scores for share of CHP in installed capacity

Country	% of CHP in installed capacity	Score
Russia	59%	2
Netherlands	41%	2
Italy	23%	1.5
Poland	20%	1.5
Taiwan	17%	1.5
Germany	16%	1.5
South Korea	11%	1
China	11%	1
Turkey	9%	0.5
Thailand	8%	0.5
Brazil	7%	0.5
Canada	7%	0.5
US	7%	0.5
UK	7%	0.5
Spain	5%	0.5
Australia	5%	0.5
India	5%	0.5
Mexico	4%	0
France	4%	0
Japan	3%	0
Indonesia	< 2%	0
Saudi Arabia	< 1%	0
South Africa	< 1%	0

Sources: WEC 2016c; IEA 2014b.

CHP POLICY (2 POINTS)

Countries can encourage or discourage CHP deployment in many ways. This new metric recognizes countries for their adoption of policies and other regulations that promote the deployment of CHP systems. First, we looked for the presence of a national goal or target for CHP. Second, we looked for other supportive policies such as tax credits, financial incentives, or regulatory support for CHP production. Countries could earn up to 2 points for policies to encourage CHP.

We awarded the full 2 points to countries with both a national target for CHP deployment and supportive policies such as incentives in place. Countries with either a national target or incentives received 1 point. Policies in some countries may apply primarily to a segment of CHP systems, which may be determined by the type of fuel resources locally available or a system size that is optimal for certain industries. For example, CHP policies in India and

Brazil are mostly limited to biomass-based applications and apply mainly in the sugar industries. Table 35 details the criteria and scores for CHP policy.

Table 35. Scores for CHP policy

Country	CHP target	CHP incentives	Score
Germany	Yes	Yes	2
India	Yes	Yes	2
Japan	Yes	Yes	2
US	Yes	Yes	2
Brazil	No	Yes	1
Canada	No	Yes	1
China	Yes	No	1
France	No	Yes	1
Italy	No	Yes	1
Mexico	No	Yes	1
Netherlands	No	Yes	1
Poland	No	Yes	1
South Africa	Yes	No	1
South Korea	No	Yes	1
Taiwan	No	Yes	1
UK	No	Yes	1
Australia	No	No	0
Indonesia	No	No	0
Russia	No	No	0
Saudi Arabia	No	No	0
Spain	No	No	0
Thailand	No	No	0
Turkey	No	No	0

Sources: IEA 2014b; IEA 2016d; ACEEE country research.

STANDARDS FOR MOTORS (2 POINTS)

Electric motors and the systems they drive consume between 43 and 46% of all global electricity consumption and are the single largest electricity end use (Waide and Brunner 2011). In industrial applications electric motors are used to drive pumps, fans, compressors, and other processing equipment. Many countries have established mandatory motor efficiency standards to limit the amount of energy that motors can consume. We scored this metric according to whether or not a country had MEPS in place for electric motors.

International standards classify motors on a scale of energy efficiency from lowest-efficiency (IE1) to highest-efficiency (IE4). We scored this metric according to the efficiency classification of the MEPS in place for electric motors. Countries with a MEPS of IE3 or higher earned 2 points. Countries with a MEPS of IE2 or lower earned 1 point. Table 36 includes the details and scoring for this metric.

Table 36. MEPS for motors

Country	Mandatory MEPS for motors	Score
Canada	Yes > IE3	2
France	Yes > IE3	2
Germany	Yes > IE3	2
Italy	Yes > IE3	2
Japan	Yes > IE3	2
Mexico	Yes > IE3	2
Netherlands	Yes > IE3	2
Poland	Yes > IE3	2
South Korea	Yes > IE3	2
Spain	Yes > IE3	2
UK	Yes > IE3	2
US	Yes > IE3	2
Australia	Yes	1
Brazil	Yes	1
China	Yes	1
Saudi Arabia	Yes	1
Taiwan	Yes	1
Turkey	Yes	1
India	No	0
Indonesia	No	0
Russia	No	0
South Africa	No	0
Thailand	No	0

Sources: IEA 4E 2015; CLASP 2016.

INVESTMENT IN R&D (2 POINTS)

While industrial R&D spending is not invested exclusively in energy efficiency, energy efficiency is a major focus of R&D investments, as it reduces waste and energy costs and improves competitiveness. The spending included in this metric therefore represents R&D activities carried out in the business enterprise sector regardless of the origin of funding. We

divided total R&D spending in the industrial sector by industrial GDP and report the results in US dollars.

We gave countries the full 2 points for investment in R&D equal to or more than 8% of industrial GDP, and 1.5 points for investment equal to or more than 5% of industrial GDP. Investment greater than 3% earned 1 point, and investment greater than 1% earned 0.5 point. Table 37 lists the results.

Table 37. Scores for investment in industrial R&D

Country	Investment in industrial R&D in 2011 (% of industrial GDP)	Score
Japan	9.5%	2
US	8.8%	2
South Korea	8.7%	2
Taiwan	6.9%	1.5
France	6.5%	1.5
Germany	5.5%	1.5
UK	5.1%	1.5
Netherlands	4.5%	1
Brazil	4.4%	1
Australia	4.1%	1
China	3.5%	1
Canada	2.7%	0.5
Spain	2.4%	0.5
Italy	2.3%	0.5
Turkey	1.4%	0.5
Russia	1.3%	0.5
South Africa	1.0%	0
Poland	1.0%	0
India	0.8%	0
Mexico	0.5%	0
Thailand	0.4%	0
Indonesia	0.0%	0
Saudi Arabia	< 1%	0

Sources: UNESCO 2016; ACEEE 2014 (Brazil); DSIR 2013 (India); World Bank 2016e (Saudi Arabia).

ENERGY INTENSITY OF AGRICULTURE (2 POINTS)

The energy intensity of the agricultural sector across countries greatly depends on the processes involved and the climatic conditions. However, because the agricultural sector is energy intensive and economically important, there is value in evaluating it separately from other industrial sectors despite differences in crop mix and conditions across countries. The execution of various crop production practices requires direct consumption of fuel and electricity, and the production of agricultural inputs such as fertilizers and pesticides requires an indirect use of energy. Energy use can be particularly high in colder regions or in countries with heavily industrialized food production processes, while countries in warmer regions or those that still rely on human and animal labor will obviously use less energy. The energy required to transport or supply water is another factor affecting energy use and energy intensity in the agricultural sector.

We measured energy intensity in agriculture as the amount of energy consumed per dollar of agricultural GDP. Countries with an energy intensity of less than 0.05 ktoe per dollar of agricultural GDP received the full 2 points. Table 38 outlines the scoring, and table 39 lists the results by country.

Table 38. Point allocation for energy intensity of agriculture

Energy intensity of agriculture	Points
< 0.05	2
< 0.10	1.5
< 0.15	1
< 0.20	0.5
< 0.25	0

Table 39. Scores for energy intensity of agriculture

Country	Energy intensity of agriculture (ktoe/$ agricultural GDP)	Score
Saudi Arabia	0.01	2
Indonesia	0.01	2
India	0.03	2
China	0.03	2
Germany	0.04	2
Taiwan	0.04	2
Turkey	0.04	2
Russia	0.06	1.5
Japan	0.06	1.5

Country	Energy intensity of agriculture (ktoe/$ agricultural GDP)	Score
Brazil	0.07	1.5
Thailand	0.07	1.5
UK	0.07	1.5
Spain	0.07	1.5
Mexico	0.07	1.5
Italy	0.07	1.5
South Korea	0.08	1.5
Australia	0.11	1
US	0.11	1
France	0.12	1
South Africa	0.14	1
Poland	0.15	1
Canada	0.18	0.5
Netherlands	0.27	0

Source: WEC 2016b

INDUSTRY BEST PRACTICES

Germany. The energy intensity of Germany's industrial sector is relatively low compared with that of other countries, with the majority of energy used in the chemical and iron and steel industries. A voluntary agreement between German industry and the federal government to reduce CO_2 emissions has been in place since 1995 (IEA 2013). Updates in 2012 set targets for annual reductions in energy intensity until 2022 (IIP 2016a). To encourage large companies to reach savings targets, such companies are eligible for a large-scale tax exemption when they fulfill their savings goals. Germany also has a target of obtaining 25% of electricity generation from CHP by 2020. The CHP Act (Kraft-Wärme-Kopplungsgesetz, or KWK-G) provides investment support in the form of a feed-in tariff. The tariff offers an incentive payment for electricity generated by CHP, depending on the type of technology and size of the system (IIP 2016b). In 2015 the government increased its support for CHP by amending the CHP Act to provide 1.5 billion euros per year, effectively doubling the amount of financial incentives available (BMWI 2015). The German government has also encouraged the implementation of EnMS for large companies, which helps energy-intensive industries achieve emissions and energy savings targets.

Japan. Japan has developed a mix of regulatory measures, voluntary actions, and financial incentives to encourage energy efficiency in industry. The Act Concerning the Rational Use of Energy introduced mandatory energy efficiency requirements for designated industries in 1978 and continues to serve as the foundation of Japan's energy efficiency policy. It requires companies to appoint an energy manager and report on the status of energy consumption every year. In 2008 a revision to the Act introduced a benchmarking system obligating businesses to achieve specific medium-term (2015) and long-term (2020) energy efficiency targets (IIP 2016d). These requirements are supported by a tax incentive scheme, a special depreciation rate for all businesses investing in specified energy conservation and efficient equipment (ABB 2012). CHP does not contribute a significant share of Japan's total power capacity, but the government offers support to help encourage a greater contribution from it. The Ministry of Economy, Trade, and Industry (METI) has studied barriers to greater CHP deployment and established an office focused on promoting CHP in Japan. The country's Energy and Environment Council defined a CHP roadmap that aims to more than double industrial and commercial CHP capacity, to 22 gigawatts (GW) in 2030 (Pales 2013).

Italy. Italy has shown a commitment to energy efficiency in its industrial sector by establishing energy savings targets, requiring plant energy managers to meet these targets, and mandating periodic energy audits. A market-based energy efficiency certificate scheme (using white certificates) is the key tool for achieving the industrial sector's savings goal, set at 5.1 million tonnes of oil equivalent (Mtoe) (EC 2014). Italy is also among the countries with the largest share of installed CHP capacity, due in part to its policies to encourage CHP deployment. In 1992 Italy adopted a resolution known as CIP6, creating a kind of feed-in tariff that spurred the development of CHP by ensuring premium prices for the production of energy for the first eight years of generation. More recently Legislative Decree No. 20/2007 called for an increase in the use of high-efficiency cogeneration in industry. It also created incentives for CHP and other technologies including high-efficiency motors and inverters and mechanical vapor compression (ABB 2013e).

Transportation

Globally the transportation sector accounts for approximately one-quarter of end-use energy consumption (EIA 2015b). The scoring methodology in this section includes a combination of policy and performance metrics relating to energy efficiency in transportation. Countries could earn a total of 25 points across 8 different metrics that cover passenger and freight transport. We evaluated the efficiency of passenger transportation using average on-road passenger-vehicle fuel economy and annual vehicle miles traveled (VMT) per person per year across the 23 nations. We assessed passenger vehicle efficiency policy by comparing light-duty fuel economy standards. We used national spending on rail versus road facilities as an indicator of investment in alternative modes in each country, and we used the share of trips by public transport to measure the role of public transport in a given nation's transportation sector. We assessed the energy intensity of freight transport using two performance metrics: energy consumed per ton-mile and ton-mile moved per unit of GDP. We also scored countries on whether or not they have fuel efficiency standards in place for heavy-duty vehicles.

The transportation section of our analysis is heavy on performance metrics, and in keeping with our overall approach of presenting the data in the simplest form that is meaningful, we have largely avoided making adjustments to the data we present in this section to reflect other factors that may impact energy use in the transportation sector.

Countries generally did not score as well in transportation as in other sectors. India, Italy, and Japan tied for 1st place, earning the top score of 16 points out of the available 25. The average score for this section was approximately 12 points. Australia, Indonesia, Taiwan, South Africa, and Mexico earned particularly low scores in transportation, with fewer than 10 points apiece. Saudi Arabia earned the lowest score of 4 points, although this was due mainly to a lack of accessible data.

Our results show that there is still plenty of progress to be made globally in transportation. While a number of nations now have passenger-vehicle fuel efficiency standards in place, only four have set standards for heavy-duty vehicles: Canada, China, Japan, and the United States. Too many countries' transportation systems still reflect much heavier investment in roads than in public transit. Table 40 shows the scores by country for the transportation section and on each metric.

Table 40. Transportation sector scores by country

Country	Total score	Average light-duty (LD) on-road fuel economy	2025 LD fuel economy standard	Heavy-duty (HD) fuel economy standard	VMT per capita	Ton-mile per $ of GDP	Energy per ton-mile traveled (kBtus/ton-mile)	Ratio of rail to road investments	% of passenger travel by transit
Max. score	**25**	**3**	**4**	**3**	**3**	**3**	**3**	**3**	**3**
India	16	3	3	0	3	0	2	2	3
Italy	16	3	4	0	3	2	0	3	1
Japan	16	3	3	1	1	3	1	1	3
China	15	1	3	2	3	0	2	1	3
France	15	3	4	0	2	2	1	2	1
South Korea	14	1	4	0	2	2	0	2	3
UK	14	3	4	0	1	2	0	3	1
Brazil	13	2	2	0	2	0	2	2	3
Spain	13	2	4	0	1	1	1	3	1
Germany	12	2	4	0	1	1	2	1	1
Netherlands	12	2	4	0	1	2	1	1	1
Poland	12	2	4	0	1	1	2	0	2
US	12	0	3	3	0	1	3	1	1
Canada	11	1	3	3	0	1	2	0	1
Russia	11	1	0	0	2	0	3	3	2
Turkey	11	3	0	0	3	1	0	1	3
Thailand	10	3	0	0	3	1	0	1	2
Mexico	9	1	1	0	2	1	0	1	3
South Africa	9	3	0	0	3	0	0	2	1
Taiwan	9	0	0	0	2	3	0	3	1
Indonesia	8	2	0	0	3	0	1	0	2
Australia	7	0	0	0	1	1	3	1	1
Saudi Arabia	4	0	2	0	2	0	0	0	0

PASSENGER-VEHICLE FUEL ECONOMY AND FUEL ECONOMY STANDARDS FOR LIGHT-DUTY VEHICLES (3 POINTS/4 POINTS)

National fuel economy standards encourage the manufacture and eventual purchase of more-efficient vehicles. For the purposes of this metric fuel economy standards could include requirements for either miles-per-gallon or per-mile CO_2 emissions, as most CO_2 standards are met through efficiency improvements. Standards often apply not to individual-vehicle fuel economy but to the average fuel economy of a manufacturer's vehicles. A number of countries have standards in place; however many of these programs are relatively new and have yet to be fully implemented. The real-world impacts of fuel

economy standards can also sometimes be difficult to estimate due to differences between test and on-road fuel economy and the frequent addition of credit programs for manufacturers. Nevertheless, stringent standards indicate a country's commitment to improving light-duty fuel economy. The second metric, passenger-vehicle fuel economy, is a performance metric that we scored using the average on-road fuel economy of all light-duty vehicles. The presence of fuel economy standards may affect this metric, but a country may also have scored well on it simply by virtue of the prevalence of low-consuming vehicles there.

We used the ICCT's comparison of passenger-vehicle fuel economy standards to rate countries' efforts (ICCT 2015). ICCT adjusts standards in each country to reflect the relationship between that country's test cycle and the US Corporate Average Fuel Economy (CAFE) test cycle in order to fairly compare standards. Countries with standards greater than 55 mpg by 2025 received the full score of 4 points, while countries with standards between 45 and 55 mpg by 2025 received 3 points. Countries with requirements of between 40 and 45 mpg received 2 points. Requirements of at least 35 mpg by 2025 received 1 point.

Countries with average on-road light-duty fuel economy greater than 35 mpg received the full 3 points, while countries with an average between 31 and 35 mpg received 2 points and countries with an average between 25 and 30 mpg received 1 point. Table 41 lists results and scores for both metrics by country.

Table 41. Scores for fuel economy and fuel economy standards for light-duty vehicles

Country	2025 fuel economy standards (mpg)	Score
France	56.9	4
Germany	56.9	4
Italy	56.9	4
Netherlands	56.9	4
Poland	56.9	4
Spain	56.9	4
UK	56.9	4
South Korea	56.7	4
Canada	49.7	3
US	49.7	3
India	49.4	3
China	47.7	3
Japan	45.9	3
Brazil*	40.9	2

Country	Average fuel economy in 2012 (mpg)	Average fuel economy in 2012 (l/100 km)	Score
Japan	45.2	5.2	3
Turkey	42.8	5.5	3
UK	42.0	5.6	3
Italy	38.6	6.1	3
Thailand	37.9	6.2	3
India	37.3	6.3	3
South Africa	35.6	6.6	3
France	35.1	6.7	3
Indonesia	33.6	7.0	2
Spain	33.1	7.1	2
Germany	32.7	7.2	2
Brazil	32.7	7.2	2
Poland	31.0	7.6	2
Netherlands	31.0	7.6	2

Country	2025 fuel economy standards (mpg)	Score
Saudi Arabia	40.0	2
Mexico	35.1	1
Taiwan	22.3	0
Australia	N	0
Indonesia	N	0
Russia	N	0
South Africa	N	0
Thailand	N	0
Turkey	N	0

Country	Average fuel economy in 2012 (mpg)	Average fuel economy in 2012 (l/100 km)	Score
Mexico	29.8	7.9	1
China	28.3	8.3	1
Russia	27.7	8.5	1
Canada	27.4	8.6	1
South Korea	27.0	8.7	1
Taiwan	24.2	9.7	0
US	21.5	10.9	0
Australia	21.2	11.1	0
Saudi Arabia	n/a	n/a	0

* Brazil's fuel economy standard is voluntary although there are numerous incentives for compliance in place. N indicates no fuel economy standard. *Sources:* ICCT 2016; ICCT 2015; Odyssey-MURE 2015; Körner et al. 2014 (Indonesia, South Africa, Thailand, and Turkey); EIA 2015a (United States); Australian Bureau of Statistics 2013; ACEEE Taiwan data request.

VEHICLE MILES TRAVELED PER CAPITA (3 POINTS)

Improved vehicle fuel economy will not adequately address energy use long term in the transportation sector if growth in VMT goes unchecked. A VMT-per-capita metric provides insight into the demand for mobility that is served by passenger cars in a country. For this metric we used the total miles traveled in a year by passenger cars in a country, divided by its population in that year. The relative rankings show how countries compare in the use of personal cars per capita. A number of factors affect VMT in a nation, suggesting a variety of possible normalizations. We used VMT per capita in keeping with our overall approach of presenting the data in the simplest form that is meaningful across the 23 nations.

Countries with an average VMT per capita of no more than 1,000 received 3 points; with no more than 3,000, 2 points; and with no more than 6,000, 1 point. Table 42 summarizes VMT per capita and all countries' scores. We present the data in both VMT and VKT (vehicle kilometers traveled). This metric tends to favor developing countries with low personal-vehicle ownership, although Italy is also among the top scorers.

Table 42. Scores for VMT per person by country

Country	VMT per capita (2012)	VKT per capita (2012)	Score
India	114	184	3
Indonesia	237	381	3
Thailand	522	841	3
China	610	981	3
South Africa	719	1,157	3
Turkey	788	1,268	3
Italy	799	1,285	3
Saudi Arabia	1,222	1,967	2
Brazil	1,462	2,353	2
Mexico	1,554	2,501	2
France	1,810	2,912	2
Russia	1,933	3,111	2
Taiwan	2,136	3,438	2
South Korea	2,611	4,202	2
Japan	3,012	4,847	1
Spain	3,177	5,112	1
Netherlands	3,632	5,845	1
Poland	3,783	6,089	1
Germany	4,149	6,677	1
UK	4,750	7,645	1
Australia	5,180	8,336	1
Canada	6,228	10,023	0
US	8,482	14,179	0

Sources: ICCT 2016; ITF 2013; Turkish Statistical Institute 2015; ACEEE Taiwan data request.

USE OF PUBLIC TRANSIT (3 POINTS)

The use of public transit is an important factor in the efficiency of a country's overall transportation system. We measured public transit use in the 23 nations evaluated in this report by dividing the distance passengers traveled via rail, bus, and coach by the total distance passengers traveled across all motorized modes of inland travel (excluding motorcycles). As in the case of VMT per capita, this metric does not capture a number of factors that indirectly affect the use of public transport in a country. Nevertheless, because

public transit is typically more energy efficient than private vehicles, we rated the percentage of passenger travel made on buses and trains.

Countries where at least 35% of travel is completed by public transit received a full score of 3 points; at least 20% by public transit, 2 points; and at least 8%, 1 point. Table 43 below lists the results for this metric.

Table 43. Scores for use of public transit

Country	Distance traveled by public transit (% passenger km by public transit modes in 2011)	Score
China	71%	3
Mexico	51%	3
India	46%	3
South Korea	42%	3
Turkey	41%	3
Japan	37%	3
Brazil	37%	3
Indonesia	30%	2
Thailand	27%	2
Russia	26%	2
Poland	23%	2
Spain	19%	1
Netherlands	19%	1
Italy	18%	1
Germany	15%	1
Taiwan	15%	1
France	15%	1
South Africa	15%	1
UK	13%	1
Australia	12%	1
US	10%	1
Canada	8%	1
Saudi Arabia	n/a	0

Data for South Africa are from 2013; data for Taiwan and Thailand are from 2012. *Sources:* ICCT 2016; ITF 2015; Statistics South Africa 2014; ACEEE Taiwan data request.

INVESTMENT IN RAIL TRANSIT VERSUS ROADS (3 POINTS)

A nation's investment in public transit is a key indicator of its commitment to energy-efficient modes of transportation. We measured each country's investment in public transit as the ratio of national investment in rail versus roads. Using investment in all transit modes would have made for a superior metric, but these data were not readily available. We recognize that in many countries transit may be funded primarily at the local level; however actions at the municipal level are beyond the scope of this *Scorecard*. Additionally, this metric does not account for other factors and actions that must occur in tandem with financial investment in order to make expenditure on public transit an effective means of managing energy use in transportation.

Countries with a spending ratio of at least 1 on rail versus roads received the full 3 points, those with a ratio of at least 0.5 to 1 received 2 points, and those with a ratio of at least 0.15 to 0.5 received 1 point. Table 44 shows the results and scores by country.

Table 44. Scores for investment in rail transit versus roads

Country	Investment in rail transit (ratio of $ in rail versus roads in 2012	Score
Taiwan	1.63	3
Italy	1.36	3
Russia	1.21	3
UK	1.13	3
Spain	1.00	3
South Africa	0.98	2
India	0.94	2
Brazil	0.68	2
France	0.67	2
South Korea	0.67	2
Netherlands	0.49	1
China	0.47	1
Australia	0.45	1
Germany	0.34	1
Turkey	0.31	1
Japan	0.29	1
Thailand	0.25	1
US	0.17	1
Mexico	0.16	1
Poland	0.10	0
Indonesia	0.09	0
Canada	0.07	0
Saudi Arabia	n/a	0

Data for China and the Netherlands are from 2011. Data for Japan are from 2010. *Sources:* OECD 2015; Emerging Market Insight 2014 (Brazil); PWC 2015 (Indonesia); DBSA 2012 and Transnet 2014 (South Africa).

ENERGY INTENSITY OF FREIGHT TRANSPORT (6 POINTS)

Freight movement accounts for a significant portion of the energy use in the transportation sector and is one of the fastest-growing uses of energy globally. To best estimate the energy intensity of the freight sector in these countries we used two different metrics. The first metric assesses the energy intensity of freight transport using the energy consumed per ton-mile of goods moved, which reflects the shares of goods moved by more and less energy-intensive modes as well as the energy efficiency of each mode. The second metric calculates the ton-miles of freight transported per dollar of GDP to evaluate freight energy use relative to economic activity, a proxy measure of the location efficiency of industrial and commercial activity.

As with the other performance-based metrics described in this section, the metrics we used to evaluate freight energy intensity may reflect differences in economic factors between the included countries, as well as demographic and geographic factors such as population density.

Table 45 shows the point allocation for both freight intensity metrics. Table 46 gives the scores.

Table 45. Point allocation for freight metrics

Energy per ton-mile traveled (kBtus/ton-mile)	Score	Ton-mile per dollar of GDP ($)	Score
≤ 0.75	3	≤ 0.08	3
≤1.2	2	≤ 0.2	2
≤ 2	1	≤ 1	1

Table 46. Scores for energy intensity of freight transport and freight transport per unit of economic activity

Country	Energy per ton-mile traveled (kBtus/ton-mile in 2012)	Energy per tonne-km traveled (MJ/tonne-km in 2012)	Score	Ton-mile per dollar of GDP in 2011	Tonne-km per dollar of GDP in 2011	Score	Total score
Australia	0.52	0.80	3	0.44	0.30	1	4
Japan	1.88	2.90	1	0.07	0.04	3	4
US	0.55	0.85	3	0.36	0.53	1	4
Canada	0.84	1.30	2	0.66	0.45	1	3
France	1.82	2.81	1	0.13	0.09	2	3
Germany	0.87	1.34	2	0.21	0.14	1	3
Netherlands	1.74	2.68	1	0.17	0.11	2	3
Poland	0.82	1.26	2	0.87	0.60	1	3
Russia	0.49	0.76	3	2.56	1.75	0	3
Taiwan	3.07	4.73	0	0.06	0.04	3	3
Brazil	1.05	1.62	2	1.06	0.72	0	2
China	1.10	1.70	2	1.89	1.30	0	2
India	1.10	1.69	2	2.31	1.58	0	2
Italy	2.61	4.02	0	0.11	0.08	2	2
South Korea	3.30	5.08	0	0.20	0.13	2	2
Spain	1.25	1.93	1	0.24	0.16	1	2
UK	2.15	3.31	0	0.10	0.07	2	2
Indonesia	1.33	2.04	1	2.06	1.41	0	1
Mexico	2.54	3.91	0	0.58	0.40	1	1
Thailand	n/a	n/a	0	0.77	0.52	1	1
Turkey	n/a	n/a	0	0.48	0.33	1	1
South Africa	n/a	n/a	0	1.55	1.06	0	0
Saudi Arabia	n/a	n/a	0	n/a	n/a	0	0

Sources: Freight intensity by ton-mile: ICCT 2016; IEA 2015a; Odyssey-MURE 2015. Freight intensity by GDP: ICCT 2016; OECD 2014; EuroStat 2016; CSIR 2013 (South Africa); Narupiti et al. 2014 (Thailand); BTS 2015 (USA).

FUEL EFFICIENCY STANDARDS FOR HEAVY-DUTY VEHICLES (3 POINTS)

Fuel efficiency standards for heavy-duty vehicles are relatively new policies for most countries but mark an important step toward capturing greater savings in the transportation sector. For purposes of this metric fuel efficiency standards include standards for either fuel consumption (e.g., gallons per ton-mile) or GHG emissions (e.g., grams CO_2 per ton-mile). We evaluated the percentage improvement the standards achieved by the end of the policy

period over a 2010 baseline. Only four countries have fuel economy standards in place for heavy-duty vehicles.

Evaluating the stringency of fuel efficiency standards using percentage improvement over a baseline year measures progress, not absolute efficiency levels. However, given the variation across countries in truck types and how they are tested, percentage improvement was a more straightforward basis for comparison. The test cycle and methodology for standard setting in the United States for instance differs significantly from the approach to heavy-duty standards in Japan.

Countries received the full 3 points for reduction goals of at least 18%, 2 points for reduction goals of at least 14%, 1 point for goals of at least 9%, and no points if they did not have a standard in place. Table 47 shows the stringency of standards and scores for each country.

Table 47. Scores for fuel efficiency standards for heavy-duty tractor trucks

Country	% reduction in fuel consumption or CO_2 emissions for tractor trucks	Score
Canada	18%	3
US	18%	3
China	14%	2
Japan	9%	1
Australia	N	0
Brazil	N	0
France	N	0
Germany	N	0
India	N	0
Indonesia	N	0
Italy	N	0
Mexico	N	0
Netherlands	N	0
Poland	N	0
Russia	N	0
Saudi Arabia	N	0
South Africa	N	0
South Korea	N	0
Spain	N	0
Taiwan	N	0

N denotes no heavy-duty fuel economy standard. *Source:* ACEEE estimates of percentage energy savings based on heavy-duty fuel economy regulation in each country.

TRANSPORTATION BEST PRACTICES

Italy. Italy retained its top spot in the 2016 edition of the ACEEE *International Energy Efficiency Scorecard*, tying with Japan and India for first place with a score of 16. The country participates in the European Union's mandatory emissions-reduction targets for new cars, which require cars registered within the Union to meet a standard of 95 grams of CO_2 per kilometer by 2021. As a result the fleet mpg average of passenger vehicles on the road in Italy is among the highest at 38.6 mpg (6.1 liters/100 km).

Italy also spends approximately 1.36 euros on rail transit facilities per euro spent on road maintenance and construction, and this expenditure is producing a trickle-down effect throughout the country. The city of Milan, the nation's economic hub, has made great strides in reducing transportation-related pollution and improving the mobility of its citizens by creating a comprehensive and interconnected public transit system. The city is served by bus, metro, tram, and trolley facilities, funded in part by federal monies.

Japan. Japan has been making progress on transportation efficiency in recent years. In the realm of system efficiency, data from 2011 show that a significant portion of passenger travel across the country occurs in non-single-occupancy vehicle modes. Approximately 37% of passenger miles are traveled on bus/coach and rail. Besides South Korea Japan is the only developed country to have achieved such a high proportion of non-passenger-car travel.

Like the European Union, Japan has fuel economy requirements in place for new passenger vehicles sold in the country. While not quite as stringent as the European Union, Japan requires all new vehicles to meet a fleet-wide average mpg standard of 45.9 mpg by 2025 (ICCT 2015). However, on top of these light-duty standards, the government implemented the world's first fuel economy standard for medium- and heavy-duty trucks in 2005. This program is expected to reduce fuel consumption for tractor trailers by nearly 10% through the life of the policy.

Conclusion

The 2016 International Energy Efficiency Scorecard compares energy use and energy efficiency policies among the top 23 largest energy consumers in the world. The rankings are dominated by European Union countries such as Germany, Italy, France, and the United Kingdom, and by East Asian nations such as Japan and China. As we mentioned in the Methodology section, we awarded full points to the top-performing country on each metric. Table 48 lists the best policies and outcomes for each.

Table 48. Highest-scoring policies and performances for each metric

Metric	Results	Countries
National efforts		
Change in energy intensity	–32.6% between 2000 and 2013	Russia
Spending on energy efficiency	$318.49 per capita	Germany
Energy savings goals	Commitments to energy savings greater than 1% per year	France, Germany, Japan, Netherlands, Poland
Efficiency of thermal power plants	42.1%	Japan
Tax credits and loan programs	Federal tax credits and loan programs, both covering multiple sectors	Canada, China, France, Germany, India, Italy, Japan, Netherlands, Poland, Russia, South Africa, South Korea, Thailand, United States
Spending on energy efficiency R&D	$4.70 per capita	Germany
Size of the ESCOs market	0.15% of total GDP	Taiwan
Water efficiency policy	A national policy in place for improving water efficiency and conservation	Australia, Canada, China, France, India, Indonesia, Italy, Japan, Netherlands, Poland, Saudi Arabia, South Africa, South Korea, Spain, Taiwan, Thailand, Turkey
Data availability	Widely available data	Australia, Canada, France, Germany, Italy, Japan, Mexico, Netherlands, Poland, Russia, South Korea, Spain, United Kingdom, United States
Buildings		
Appliance and equipment standards	60 mandatory appliance and equipment standards	United States
Residential building codes	Mandatory building codes covering all 6 technical-requirement categories	Australia, Germany, South Africa
Commercial building codes	Mandatory building codes covering 5 out of 6 technical-requirement categories	Australia, Germany, South Africa
Building retrofit policies	Mandatory; upgrades required within a specific time frame	France, Germany

Metric	Results	Countries
Building labeling	Mandatory building energy labeling and disclosure policy covering all buildings	France, Germany, Italy, Poland, Turkey, United Kingdom
Appliance and equipment labeling	Mandatory categorical program covering more than 15 product categories	China, France, Germany, Italy, Netherlands, Poland, South Korea, Spain, Turkey, United Kingdom
Energy intensity in residential buildings	0.30 MMBtus per square meter of floor space, 4.65 MMBtus per capita	Brazil
Energy intensity in commercial buildings	0.58 MMBtus per square meter of floor space, 188 MMBtus per million dollars of GDP	Brazil
Industry		
Energy intensity of the industrial sector	1.3 kBtus/$ GDP	United Kingdom
Voluntary energy performance agreements with manufacturers	Government agreements with manufacturers and incentives for a variety of business types	Canada, China, France, Germany, India, Italy, Russia, South Africa, South Korea, Spain, Thailand, Turkey, United Kingdom
Policy to encourage energy management	Energy management policy that references ISO 50001	Canada, China, Germany, India, Indonesia, Japan, Mexico, Russia, South Korea, Spain, Taiwan, Thailand, Turkey, United Kingdom, United States
Minimum efficiency standards for electric motors	Mandatory IE3 MEPS	Canada, France, Germany, Italy, Japan, Mexico, Netherlands, Poland, South Korea, Spain, United Kingdom, United States
Mandate for plant energy managers	Requirement for a dedicated onsite energy expert	China, India, Indonesia, Italy, Japan, Taiwan, Thailand, Turkey
Mandatory energy audits	Requirement for periodic energy audits of facilities	China, France, Germany, India, Indonesia, Italy, Japan, Netherlands, Poland, South Korea, Spain, Taiwan, Thailand, United Kingdom
Investment in manufacturing R&D	9.5% of total industrial GDP	Japan
Share of CHP in total installed capacity	59%	Russia
Policy to encourage CHP	Targets for CHP share of energy production and incentives to encourage CHP deployment	Germany, India, Japan, United States

Metric	Results	Countries
Agriculture energy intensity	0.01 ktoe per $ of agricultural GDP	Saudi Arabia, Indonesia
Transportation		
Fuel economy standards for light-duty vehicles	56.9 mpg by 2025	France, Germany, Italy, Netherlands, Poland, Spain, United Kingdom
Fuel economy of light-duty vehicles	45.2 mpg	Japan
Vehicle miles traveled per capita	114 vehicle miles traveled per capita	India
Fuel economy standards for heavy-duty tractor trucks	18% improvement in fuel consumption/CO_2 emissions of tractor trucks	United States, Canada
Freight transport per unit economic activity	0.06 ton-miles per $ of GDP	Taiwan
Energy intensity of freight transport	0.5 kBtus per ton-mile	Russia
Use of public transit	70.6% of total passenger kilometers traveled	China
Investment in rail transit versus roads	$1.63 spent on transit per $1 spent on roads	Taiwan

Although no country achieved a perfect overall score in this year's *Scorecard*, 13 countries scored above 50 points. The average score of 51 remained unchanged in 2016. Countries generally did better compared to the *2014 Scorecard*. The highest score earned this year was 73.5 compared to 65 in 2014.

The United States in particular made significant progress in the rankings since the 2014 edition where it ranked in 13th place, below Australia, India, and South Korea. In 2016 the United States ranked 8th out of the 23 evaluated countries, with a total score of 61.5 points. Changes in our scoring methodology may have been the most significant cause of improved US performance.

Overall a number of factors caused changes in country scores in this edition. First, several countries made actual progress in their policies and performance. The fact that we added eight new countries also widened the range of possible scores. Finally, we made changes in our overall set of metrics and in the weighting of policy versus performance. Many of the more developed high-energy-use countries received additional points this year for the policies they have in place to reduce energy consumption.

Despite an overall improvement in scores in 2016, significant—and in some cases dramatic—room for improvement remains across all the countries analyzed in this edition. It is true that many countries have implemented countrywide energy-reduction and GHG-reduction targets as well as a suite of complementary policies in an effort to spur energy savings, technology development, and economic development. Yet more needs to be done to improve sector-specific efficiency. This is particularly true in the transportation and buildings sectors, where the top scores were a mere 16 and 18 points, respectively, out of a possible 25.

The countries with the most room for improvement include some of the new additions to the 2016 report, such as Indonesia, Thailand, and South Africa. While it is important to note that many of this year's low-scoring countries are emerging economies with increasing demand for energy services, they still have plenty of opportunity to build energy efficiency into their continued economic growth by implementing policies in their industrial, buildings, and transportation sectors.

Nations can learn from one another by emulating best policies, practices, and performance. More-developed countries have a responsibility to lead by example and implement ambitious policies that will further reduce energy consumption. Countries that use energy more efficiently use fewer resources to achieve the same goals, thereby reducing overall costs, preserving valuable natural resources, and gaining a competitive edge over countries where resources are wasted and costs are higher.

References

ABB (ASEA Brown Boveri). 2012. *Japan Energy Efficiency Report*. Zurich: ABB. library.e.abb.com/public/cd8e2662ae4b1340c12579d0004f1b13/Japan%20Energy%20efficiency%20Report.pdf.

——. 2013a. *Canada Energy Efficiency Report*. Zurich: ABB. library.e.abb.com/public/1c9d51f900ec29a5c1257be800533b5e/Canada.pdf.

——. 2013b. *China Energy Efficiency Report*. Zurich: ABB. library.e.abb.com/public/1ec04ca97f31b433c1257be800535916/China.pdf.

——. 2013c. *India Energy Efficiency Report*. Zurich: ABB. library.e.abb.com/public/478c519db9feeae1c1257be800545aee/India.pdf.

——. 2013d. *Indonesia Energy Efficiency Report*. Zurich: ABB. library.e.abb.com/public/215e27d2819ee70bc1257be800547219/Indonesia.pdf.

——. 2013e. *Italy Energy Efficiency Report*. Zurich: ABB. library.e.abb.com/public/25e989a42ad4c799c1257be800549d00/Italy.pdf.

——. 2013f. *Russia Energy Efficiency Report*. Zurich: ABB. library.e.abb.com/public/6ef634a1f5944b10c1257be80055b849/Russia.pdf.

——. 2013g. *South Korea Energy Efficiency Report*. Zurich: ABB. library.e.abb.com/public/557d50223ed20a76c1257beb0044f3bc/South Korea.pdf.

——. 2013h. *Turkey Energy Efficiency Report*. Zurich: ABB. library.e.abb.com/public/a2c92d1d4f7f2405c1257be9002c5060/Turkey.pdf.

ACEEE. 2016. "Financial Incentives for Energy Efficiency." Accessed February. aceee.org/topics/financial-incentives-energy-efficiency.

Australian Bureau of Statistics. 2013. *Survey of Motor Vehicle Use*. Canberra: Australian Bureau of Statistics. www.ausstats.abs.gov.au/Ausstats/subscriber.nsf/0/79248942569F5126CA257B55002304F0/$File/92080_12 months ended 30 june 2012.pdf.

BEA (Department of Commerce, Bureau of Economic Analysis). 2006. "Frequently Asked Questions." www.bea.gov/faq/index.cfm?faq_id=184.

Bertoldi, P., B. Boza-Kiss, S. Panev, and N. Labanca. 2014. *ESCO Market Report 2013*. Luxembourg: EC. iet.jrc.ec.europa.eu/energyefficiency/sites/energyefficiency/files/jrc_89550_the_european_esco_market_report_2013_online.pdf.

BMWI (Bundesministerium für Wirtschaft und Energie). 2015. "Gabriel: Cabinet Decision on the Promotion of Cogeneration Strengthens Efficient Heat and Power Supply." September 23. www.bmwi.de/DE/Presse/pressemitteilungen,did=727468.html.

BPIE (Buildings Performance Institute Europe). 2011. *Europe's Buildings under the Microscope: A Country-by-Country Review of the Energy Performance of Buildings*. Brussels: BPIE. bpie.eu/wp-content/uploads/2015/10/HR_EU_B_under_microscope_study.pdf.

——. 2014. *Renovation Strategies of Selected EU Countries: A Status Report on Compliance with Article 4 of the Energy Efficiency Directive*. Brussels: BPIE. bpie.eu/uploads/lib/document/attachment/86/Renovation_Strategies_EU_BPIE_2014.pdf.

——. 2015. *Renovation in Practice: Best Practice Examples of Voluntary and Mandatory Initiatives across Europe.* Brussels: BPIE. bpie.eu/wp-content/uploads/2015/12/BPIE_Renovation_in_practice_2015.pdf.

BTS (Bureau of Transportation Statistics, Department of Transportation). 2015. "U.S. Ton-Miles of Freight." Accessed October. www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_01_50.html.

CCAP (Center for Clean Air Policy). 2013. *Revolving and ESCO Funds for Renewable Energy and Energy Efficiency Finance – Thailand*. Washington, DC: CCAP. ccap.org/assets/CCAP-Booklet_Thailand.pdf.

CLASP. 2016. "Global Standards and Labeling Database." Accessed February. clasp.ngo/en/Tools/Tools/SL_Search.

CSIR (Council for Scientific and Industrial Research). 2013. *9th Annual State of Logistics™ Survey for South Africa 2012: Connecting Neighbours – Engaging the World*. Pretoria: CSIR. www.csir.co.za/sol/docs/final_9th SoL for web.pdf.

DBSA (Development Bank of South Africa). 2012. *The State of South Africa's Economic Infrastructure: Opportunities and Challenges*. Pretoria: DBSA. www.dbsa.org/EN/About-Us/Publications/Documents/State of economic infrastructure 2012.pdf.

DOE (Department of Energy). 2014. *Analysis of the Chinese Market for Building Energy Efficiency*. Washington, DC: DOE. www.globalchange.umd.edu/data/seminars/2014-10-29-China_Bldg_EE_Opportunities.pdf.

——. 2016. "Getting Started with ISO 50001." Accessed April. www.energy.gov/eere/amo/getting-started-iso-50001.

DSIR (Department of Scientific & Industrial Research, Ministry of Science & Technology). 2013. *Sectoral Innovation Council on Industrial R&D*. New Delhi: DSIR. www.mygov.in/sites/default/files/master_image/DSIR_whitepaper_on_Industrial_RD.pdf.

EIA (Energy Information Administration). 2012. "International Energy Statistics: Total Primary Energy Consumption." www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=44&pid=44&aid=2.

——. 2013. "2010 Manufacturing Energy Consumption Survey Data." www.eia.gov/consumption/manufacturing/data/2010/.

——. 2015a. *Annual Energy Outlook 2015*. Washington, DC: EIA. www.eia.gov/forecasts/aeo/pdf/0383(2015).pdf.

——. 2015b. "Frequently Asked Questions: How Much Energy Is Consumed in the World by Each Sector?" www.eia.gov/tools/faqs/faq.cfm?id=447&t=1.

——. 2016. "International Energy Statistics." Accessed May. www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm.

Emerging Markets Insight. 2014. *Infrastructure Sector: Brazil*. New York: EMIS (Emerging Markets Information Service). www.emis.com/sites/default/files/EMIS Insight Brazil Infrastructure Sector.pdf.

EC (European Commission). 2014. *Italian Energy Efficiency Action Plan 2014*. Luxembourg: EC. ec.europa.eu/energy/sites/ener/files/documents/2014_neeap_en_italy.pdf.

Evans, M., B. Shui, and A. Delgado. 2009. *Shaping the Energy Efficiency in New Buildings – A Comparison of Building Energy Codes in the Asia-Pacific Region*. Washington, DC: DOE. www.energycodes.gov/sites/default/files/documents/CountryReport_APP_Building_Code_Comparison.pdf.

ICCT (International Council on Clean Transportation). 2015. "Global Passenger Vehicle Standards." www.theicct.org/info-tools/global-passenger-vehicle-standards.

——. 2016. "Global Transportation Roadmap Model." Accessed January. www.theicct.org/global-transportation-roadmap-model.

IEA (International Energy Agency). 2013. *Policy Pathway: Modernising Building Energy Codes to Secure Our Global Energy Future*. Paris: IEA. www.iea.org/publications/freepublications/publication/PolicyPathwaysModernisingBuildingEnergyCodes.pdf.

——. 2014a. *Capturing the Multiple Benefits of Energy Efficiency: Executive Summary*. Paris: IEA. www.iea.org/Textbase/npsum/MultipleBenefits2014SUM.pdf.

——. 2014b. *World Energy Outlook*. Paris: IEA.

——. 2015a. *Energy Efficiency Market Report 2015*. Paris: IEA. www.iea.org/publications/freepublications/publication/MediumTermEnergyefficiencyMarketReport2015.pdf.

——. 2015b. *Key Electricity Trends – Excerpt from Electricity Information.* Paris: IEA. www.iea.org/publications/freepublications/publication/Electricitytrends.pdf.

——. 2015c. *Key World Energy Statistics*. Paris: IEA. www.iea.org/publications/freepublications/publication/KeyWorld_Statistics_2015.pdf.

——. 2016a. "Energy Efficiency." Accessed February. www.iea.org/aboutus/faqs/energyefficiency/.

——. 2016b. "IEA CHP/DHC Country Scorecards." Accessed February. www.iea.org/chp/countryscorecards/.

——. 2016c. "IEA Energy Technology RD&D Statistics." Accessed February. www.oecd-ilibrary.org/energy/data/iea-energy-technology-r-d-statistics_enetech-data-en;jsessionid=s42kmlau2qhn.x-oecd-live-02.

——. 2016d. "Policies and Measures Database." Accessed February. www.iea.org/policiesandmeasures/.

——. 2016e. "Statistics Search: Balances." Accessed April. www.iea.org/statistics/statisticssearch/.

——. 2016f. "World Energy Balance Sankey Diagram 2013." Accessed June. www.iea.org/sankey/.

IEA 4E (International Energy Agency Implementing Agreement on Energy Efficient End-Use Equipment). 2015. *Energy Efficiency Roadmap for Electric Motors and Motor Systems.* Paris: IEA. www.iea.org/media/openbulletin/4e_roadmap_for_motors_and_vfd_oct2015.pdf.

Pales, A. 2013. *CHP/DHC Country Scorecard: Japan*. Paris: IEA. www.iea.org/publications/insights/insightpublications/IEAJapanScorecardMASTERFINALdraft_060913_AF.pdf.

IIP (Institute for Industrial Productivity). 2016a. "GE-2: Voluntary Agreements with German Industry." Accessed April. iepd.iipnetwork.org/policy/voluntary-agreements-german-industry.

——. 2016b. "GE-5: CHP Law (Kraft Wärme Kopplungsgesetz)." Accessed April. iepd.iipnetwork.org/policy/chp-law-kraft-wärme-kopplungsgesetz.

——. 2016c. "Industrial Efficiency Programs Database." Accessed January, www.iipnetwork.org/databases/programs?field_program_type_p=290.

——. 2016d. "JP-3: Mandatory Energy Efficiency Benchmarking in Industry." Accessed April. iepd.iipnetwork.org/policy/mandatory-energy-efficiency-benchmarking-industry.

IMT (Institute for Market Transformation). 2016. "Buildingrating.org Database." Accessed April. buildingrating.org/search/site.

IPEEC (International Partnership for Energy Efficiency Cooperation). 2015a. *Building Energy Performance Metrics: Supporting Energy Efficiency Progress in Major Economies*. Paris: IPEEC. www.buildingrating.org/sites/default/files/1448011796IEA_IPEEC_BEET4_Final_Report.pdf.

——. 2015b. *Delivering Energy Savings in Buildings*. Paris: IPEEC. ipeec.org/publications/download/id/1962.html.

——. 2016a. *Building Code Implementation – Country Summary: India.* Paris: IPEEC. www.gbpn.org/sites/default/files/India_Country Summary.pdf.

——. 2016b. *Building Code Implementation – Country Summary: Indonesia.* Paris: IPEEC. www.gbpn.org/sites/default/files/Indonesia_Country Summary_0.pdf.

——. 2016c. *Building Code Implementation – Country Summary: Italy.* Paris: IPEEC. www.gbpn.org/sites/default/files/Italy_Country Summary.pdf.

——. 2016d. *Building Code Implementation – Country Summary: Japan.* Paris: IPEEC. www.gbpn.org/sites/default/files/Japan_Country Summary_0.pdf.

——. 2016e. *Building Code Implementation – Country Summary: Mexico.* Paris: IPEEC. www.gbpn.org/sites/default/files/Mexico_Country Summary.pdf.

——. 2016f. *Building Code Implementation – Country Summary: Saudi Arabia.* Paris: IPEEC. www.gbpn.org/sites/default/files/Saudi Arabia_Country Summary_0.pdf.

——. 2016g. *Building Code Implementation – Country Summary: South Africa.* Paris: IPEEC. www.gbpn.org/sites/default/files/South Africa_Country Summary_0.pdf.

——. 2016h. *Building Code Implementation – Country Summary: South Korea.* Paris: IPEEC. www.gbpn.org/sites/default/files/South Korea_Country Summary_0.pdf.

——. 2016i. *Building Code Implementation – Country Summary: Turkey.* Paris: IPEEC. www.gbpn.org/sites/default/files/Turkey_Country Summary_0.pdf.

——. 2016j. *Building Code Implementation – Country Summary: UK.* Paris: IPEEC. www.gbpn.org/sites/default/files/UK_Country Summary_0.pdf.

——. 2016k. *Building Code Implementation – Country Summary: USA*. Paris: IPEEC. www.gbpn.org/sites/default/files/USA_Country Summary_0.pdf.

——. 2016l. "G20 Policies and Measures Database." Accessed March. g20-energy-efficiency.enerdata.net/policies/.

ITF (International Transport Forum). 2013. *Key Transport Statistics: 2012 Data*. Paris: ITF. www.itf-oecd.org/sites/default/files/docs/13keystat2012.pdf.

——. 2015. "Passenger Transport." Accessed October. stats.oecd.org/Index.aspx?&datasetcode=ITF_PASSENGER_TRANSPORT.

ISO (International Organization for Standardization). 2014. "ISO Survey." www.iso.org/iso/iso-survey.

——. 2016. "ISO 50001:2011 Energy Management Systems—Requirements with Guidance for Use." Accessed April. www.iso.org/obp/ui/ - iso:std:iso:50001:ed-1:v1:en.

Körner, A., P. Cazzola, and F. Cuenot. 2014. *International Comparison of Light-Duty Vehicle Fuel Economy: Evolution over 8 Years from 2005 to 2013*. Paris: IEA. ledsgp.org/wp-content/uploads/2016/01/wp11-iea-report-update-2014.pdf.

McKane, A., D. Desai, M. Matteini, W. Meffert, R. Williams, and R. Risser. "Thinking Globally: How ISO 50001—Energy Management Can Make Industrial Energy Efficiency Standard Practice." In *Proceedings of the 2009 ACEEE Summer Study on Energy Efficiency in Industry* 5:65–76. Washington, DC: ACEEE. aceee.org/files/proceedings/2009/data/papers/5_79.pdf.

Narupiti, S., A. Tippichai, P. Nanthachatchavankul, M. Sutjaritthanarak, and S. Bakker. 2014. *Thailand Stocktaking Report on Sustainable Transport and Climate Change: Data, Policy and Monitoring*. Bangkok: ASEAN German Technical Coordination. transportandclimatechange.org/wp-content/uploads/2014/10/GIZ-TCC_Thailand-Stocktaking-Report-September-2014.pdf.

Odyssee-MURE. 2015. "Key Indicators." Accessed October. www.indicators.odyssee-mure.eu/online-indicators.html.

OECD (Organisation for Economic Cooperation and Development). 2014. *OECD Factbook 2014: Economic, Environmental and Social Statistics*. Paris: OECD. www.oecd-ilibrary.org/economics/oecd-factbook-2014_factbook-2014-en.

——. 2015. "Infrastructure Investment." Accessed December. data.oecd.org/transport/infrastructure-investment.htm.

Panev, S., N. Labanca, P. Bertoldi, T. Serrenho, C. Cahill, and B. Boza-Kiss. 2014. *ESCO Market Report for Non-European Countries 2013.* Luxembourg: European Commission. publications.jrc.ec.europa.eu/repository/bitstream/JRC92730/ld-na-26989-en-c%28print%29.pdf.

PwC (PricewaterhouseCoopers). 2015. *Building Indonesia's Future: Unblocking the Pipeline of Infrastructure Projects*. Jakarta: PwC. www.pwc.com.au/asia-practice/publications/pwc_outlook_-_unblocking_the_pipeline_of_infrastructure_projects_c.pdf.

Republic of China. 2016. "Laws & Regulations Database of the Republic of China." Accessed April. law.moj.gov.tw/Eng/LawClass/LawAll.aspx?PCode=D0070109.

SANEDI (South African National Energy Development Institute). *12L Energy Efficiency Tax Incentive: Frequently Asked Questions*. Pretoria: SANEDI.

Solidiance. 2013. *Thailand's Green Buildings Goals: Aspirations & Realities*. Bangkok: Solidiance. www.solidiance.com/whitepaper/thailands-green-building-goals-aspirations-vs-realities.pdf.

SRI (SRI International). 2015. *Saving Energy, Building Skills: Industrial Assessments Program Impacts.* Washington, DC: SRI. iac.university/technicalDocs/Industrial Assessment Centers Impacts SRI International.pdf.

Statistics South Africa. 2014. *National Household Travel Survey 2013*. Pretoria: Statistics South Africa. www.statssa.gov.za/publications/P0320/P03202013.pdf.

Transnet. 2013. *Annual Report 2013*. Pretoria: Transnet.

Turkish Statistical Institute. 2015. "Transportation Statistics." Accessed October. www.turkstat.gov.tr/PreTablo.do?alt_id=1051.

UNECE (United Nations Economic Commission for Europe). 2004. *Bulletin of Housing Statistics for Europe and North America 2004*. Geneva: UNECE. www.unece.org/hlm/prgm/hsstat/Bulletin_04.html.

UNESCO (United Nations Educational, Scientific, and Cultural Organization). 2016. "GERD by Sector of Performance." Accessed April. data.uis.unesco.org/?queryid=81

UNFCCC (United Nations Framework Convention on Climate Change). 2016. "INDCs as Communicated by Parties." Accessed February. www4.unfccc.int/submissions/INDC/Submission Pages/submissions.aspx.

Waide, P., and C. Brunner. 2011. *Energy-Efficiency Policy Opportunities for Electric Motor-Driven Systems.* Paris: IEA. www.iea.org/publications/freepublications/publication/EE_for_ElectricSystems.pdf.

WEC (World Energy Council). 2016a. "Efficiency of Thermal Power Plants." Accessed January. www.wec-indicators.enerdata.eu/power-plants-thermals.html.

——. 2016b. "Energy Intensity of Agriculture." Accessed January. www.wec-indicators.enerdata.eu/agriculture-energy-intensity.html.

——. 2016c. "Share of Industrial CHP in Industrial Electricity Consumption." Accessed January. www.wec-indicators.enerdata.eu/industrial-chp.html.

World Bank. 2009. *Reducing Technical and Non-Technical Losses in the Power Sector*. Washington, DC: World Bank.

siteresources.worldbank.org/EXTESC/Resources/Background_paper_Reducing_losses_in_the_power_sector.pdf.

——. 2016a. "Electric Power Transmission and Distribution Losses (% of Output)." Accessed February. data.worldbank.org/indicator/EG.ELC.LOSS.ZS.

——. 2016b. "GDP at Market Prices (Constant 2005 US$)." Accessed April. data.worldbank.org/indicator/NY.GDP.MKTP.KD/countries/1W?display=default.

——. 2016c. "GDP at Market Prices (Current US$)." Accessed April. data.worldbank.org/indicator/NY.GDP.MKTP.CD/countries?display=default.

——. 2016d. "Industry, Value Added (% of GDP)." Accessed April. data.worldbank.org/indicator/NV.IND.TOTL.ZS.

——. 2016e. "Population, Total." Accessed April. data.worldbank.org/indicator/SP.POP.TOTL?display=default.

Young, R. 2013. *Saving Water and Energy Together: Helping Utilities Build Better Programs*. Washington, DC: ACEEE. aceee.org/research-report/e13h.

——. 2014. "Global Approaches: A Comparison of Building Energy Codes in 15 Countries." In *Proceedings of the ACEEE Summer Study on Energy Efficiency in Buildings* 3:352–366. Washington, DC: ACEEE. aceee.org/files/proceedings/2014/data/papers/3-606.pdf.

Young, R., S. Hayes, M. Kelly, S. Vaidyanathan, S. Kwatra, R. Cluett, and G. Herndon. 2014. *2014 International Energy Efficiency Scorecard.* Washington, DC: ACEEE. aceee.org/research-report/e1402.

Appendix A. Energy Intensity

Accurately evaluating the energy intensity of a given economic sector in a country is challenging. Numerous factors besides energy efficiency impact energy intensity values, including climate, economic composition, and population. As a result isolating the impact of energy efficiency measures on energy use is difficult. For *The 2016 International Energy Efficiency Scorecard*, we used the following methodologies for our buildings- and industry-sector intensity metrics. These approaches allowed us to fairly compare intensity across the 23 countries evaluated in the report by accounting for large differences in climate and economy.

ENERGY INTENSITY OF RESIDENTIAL BUILDINGS

We adjusted the share of residential-building energy intensity used for heating and cooling for variations in climate between countries. To achieve this we first collected data on the percentage of overall energy use that heating and cooling account for in each country. We then calculated the building energy intensity of space heating and cooling separately based on the share of overall energy use that heating and cooling loads account for in each country.

$$\begin{aligned} &Energy\ intensity\ of\ space\ heating\ (E^{H}) \\ &= Energy\ intensity\ (E^{0}) * Share\ of\ space\ heating\ in\ residential\ energy\ use \end{aligned}$$

$$\begin{aligned} &Energy\ intensity\ of\ space\ cooling\ (E^{C}) \\ &= Energy\ intensity\ (E^{0}) * Share\ of\ space\ cooling\ in\ residential\ energy\ use \end{aligned}$$

E^0 is the original energy intensity we calculated using total residential energy use in a country (separately by floor area and by population). $E^H$and E^C therefore are real values that reflect heating and cooling energy intensities in the countries.

Next we calculated the ratio of each country's heating and cooling degree days (assuming a comfort temperature of 65°F) to the average number of heating and cooling degree days of all the countries analyzed.

$$HDD\ ratio = HDD\ of\ country * Average\ HDD\ of\ all\ countries$$

$$CDD\ ratio = CDD\ of\ country * Average\ CDD\ of\ all\ countries$$

We used these ratios to normalize the energy intensities of space heating and space cooling. We divided the intensities for space heating and cooling ($E^H$and E^C) by the HDD and CDD ratios, respectively, to derive energy intensities for space conditioning as if all the countries had the same climate.

$$Climate\ adjusted\ energy\ intensity\ of\ space\ heating\ (E^{HC}) = \frac{E^{H}}{HDD\ ratio}$$

$$Climate\ adjusted\ energy\ intensity\ of\ space\ cooling\ (E^{CC}) = \frac{E^{C}}{CDD\ ratio}$$

Finally, we added the climate adjusted space heating and cooling intensities to the unweighted portion of the original intensity.

$$Final\ relative\ energy\ intensity\ (E^F) = (E^0 - E^{\mathrm{H}} - E^{\mathrm{C}}) + E^{\mathrm{HC}} + E^{\mathrm{CC}}$$

We followed the same methodology for both residential intensity metrics: energy use per floor area and energy use per capita. The adjustment serves the sole purpose of allowing a fairer comparison between countries with different heating and cooling needs. The relative intensities should not be interpreted as absolute values.

ENERGY INTENSITY OF INDUSTRY

We used energy intensity to compare the efficiency of the industrial sector across countries.[5] To begin with we calculated the raw energy intensity of industry using total energy consumed and total industrial GDP (World Bank 2016) for each country. These data are readily available for all countries.

$$Raw\ energy\ intensity\ of\ a\ country's\ industry\ \ (I^{C0}) = \frac{Energy\ consumed\ by\ industry\ as\ a\ whole}{GDP\ of\ industry}$$

It would be more accurate to evaluate the energy intensity of industry as the energy consumed per dollar of value added instead of per GDP. *Value added* is the difference between an industry's gross output (sales or receipts and other operating income, commodity taxes, and inventory change) and the cost of its intermediate inputs (including energy, raw materials, semifinished goods, and services that are purchased from all sources) (BEA 2006). However this information is not available for all countries.

Using raw energy intensities alone does not offer a meaningful comparison between countries. Both the composition of the industrial sector and the energy use of individual industries vary significantly across the 23 countries analyzed. For example, in 2013 Australia's energy consumption was highest in nonferrous-metals manufacturing, while Brazil's energy consumption was highest in food and tobacco production. Additionally, the efficiency of the manufacturing process itself may vary from country to country for the same industry. Generally across most countries industries such as machinery and transport equipment tend to have high market value and low energy consumption relative to industries such as cement, pulp and paper, metal products, and chemicals, which have low market value and high energy consumption.

---

[5] The industrial sector is generally classified into four subsectors (agriculture, mining, manufacturing, and construction), which are further classified into individual industries (metals, chemicals, food, and so forth). The industry groupings used in this analysis follow the categorization of energy consumption data by the IEA. www.iea.org/statistics/resources/balancedefinitions/#industry www.iea.org/statistics/resources/balancedefinitions/#industry.www.iea.org/statistics/resources/balancedefinitions/#industry.

In order to fairly compare the energy intensities of countries' industrial sectors and to account for variation in the mix of individual industries, we developed a weighting factor we call the *relative intensity factor* to normalize raw energy intensities.

Step 1. Energy Intensities of Industry Groupings

To calculate the relative intensity factors we needed the energy intensities of industry groupings for each country. These would ideally be calculated using the energy consumption of and value added by each industry. Figure A1 shows the mix of industries in the 23 countries and the energy consumption of the 13 industry groupings as a share of total energy consumed by the industrial sector overall.[6] While energy consumption data of industry groupings were available (IEA 2016e), value-added data were not available in a consistent manner across all countries in the year we evaluated. As a substitute we used the energy intensities of US industry groupings to calculate the energy intensities of individual industries in other countries, assuming the pattern would be similar. It may be possible to improve this assumption in future editions of the *Scorecard* by approximating the intensities of individual countries' industries based on regional similarities where good data are available.

[6] For certain countries final energy consumption data reported by industry grouping did not appear consistent. For example, 98% of final energy consumption in Saudi Arabia was reported as nonspecified, which was inconsistent with the fact that hydrocarbon extraction is the country's most significant industry grouping. This allocation distorted results for the country. To approximate a more representative picture of industrial energy consumption in Saudi Arabia, we moved half of its nonspecified energy consumption to the mining and quarrying industry group. We made no adjustments for other countries, but this issue warrants further investigation.

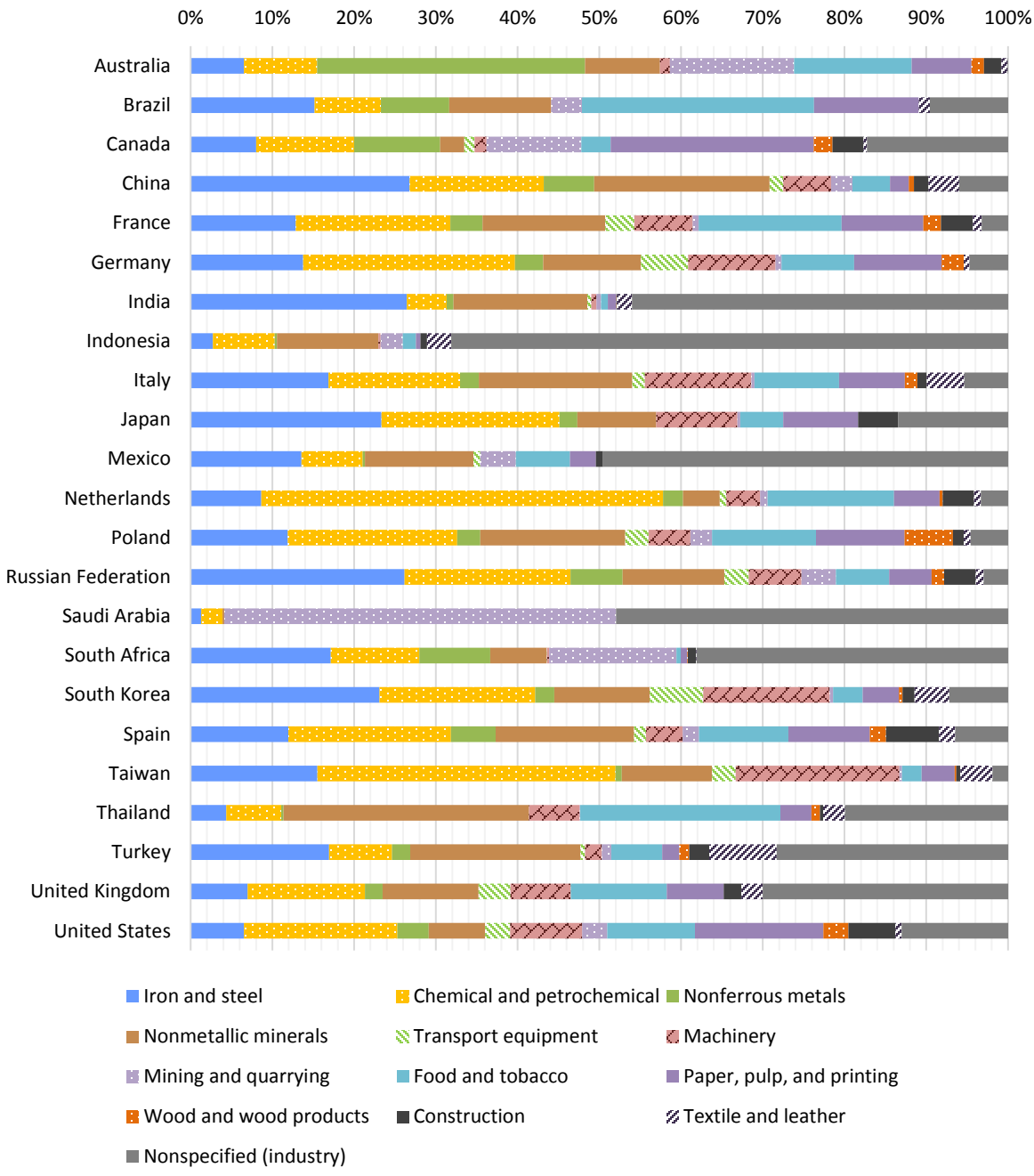


Figure A1. Industry groupings and respective shares of energy consumption by industry in analyzed countries. ***Source:*** **IEA 2016e.**

First, we calculated the energy consumed in each industry grouping in each country as a share of total energy consumed in that grouping in all 23 countries (R^{ci}).

$$Energy\ consumption\ ratio\ for\ each\ industry\ grouping\ for\ each\ country\ (R^{ci}) = \frac{Energy\ consumed\ by\ a\ country\ in\ a\ particular\ industry\ grouping}{Total\ \ energy\ consumed\ by\ all\ 23\ countries\ in\ that\ industry\ grouping}$$

Then we multiplied each grouping's share of energy consumption by the corresponding US industry intensity of that grouping. Thus we derived energy intensities for all 13 groupings of industries in each of the 23 countries analyzed.

$$Derived\ energy\ intensity\ of\ each\ industry\ grouping\ in\ each\ country\ \left(I^{ci}\right) =$$

$$R^{ci} * Corresponding\ energy\ intensity\ of\ the\ industry\ grouping\ in\ the\ United\ States$$

We based US industry intensities on energy consumption and value of shipments reported in tables 25 to 35 of the *Annual Energy Outlook 2015* (EIA 2015a). We chose to use value of shipments because recent data on value added were not available. For textile and leather manufacturing and the nonspecified sector, we used the average intensity of energy consumption per dollar of value of shipments reported in table 6.3 of the *2010 Manufacturing Energy Consumption Survey* (MECS) (EIA 2013). In future editions of the *International Scorecard* it would be helpful to use value added by manufacturing instead of value of shipments, because value added data better capture the efficiency of transforming raw materials into finished goods, and new value added data will be available from MECS.

Step 2. Relative Intensity Factors

Next we normalized these derived intensities for each country to allow us to compare across countries. To normalize we summed the derived intensities of the 13 industry groupings for each country, calculated the average of the 23 sums, and then used this average to normalize the sums themselves to produce a unit-less relative intensity factor for each country.

$$I^{cs} for\ each\ country = Sum\ of\ I^{ci} of\ 13\ industry\ groupings\ for\ the\ country$$

$$Relative\ intensity\ factor\ for\ each\ country\ (R^{c}) = \frac{I^{cs}\ of\ the\ country}{Average\ \ I^{cs}\ of\ all\ countries}$$

We then multiplied the raw energy intensities for each country by the corresponding relative intensity factors to produce a final weighted energy intensity of the overall industrial sector for each country.

$$Final\ weighted\ energy\ intensity\ for\ each\ country\ I^{w}\ =$$

$$I^{c0}(raw\ energy\ intensity) *\ R^{c}\ (relative\ intensity\ factor)$$

Table A1 shows the raw energy intensity, relative intensity factor, and weighted energy intensity for each of the 23 countries. Countries are ranked in increasing order of weighted intensities.

Table A1. Raw intensities, weighting factor, and weighted intensities of the industrial sectors

Country	Raw energy intensity (kBtus/2013$)	Relative intensity factor	Weighted energy intensity (kBtus/2013$)
United Kingdom	1.71	0.72	1.23
Indonesia	3.67	0.43	1.57
Mexico	3.17	0.60	1.89
Germany	1.91	1.08	2.07
Italy	2.07	1.04	2.15
Netherlands	2.58	0.84	2.16
France	2.00	1.09	2.18
Japan	2.52	0.88	2.22
Spain	2.45	1.18	2.90
Canada	1.82	1.60	2.92
South Korea	3.77	0.84	3.18
United States	3.02	1.17	3.54
Turkey	4.44	0.89	3.96
Taiwan	5.16	0.80	4.13
Poland	3.26	1.31	4.28
Australia	2.39	1.80	4.31
Saudi Arabia	4.09	1.05	4.31
Thailand	7.20	0.83	5.96
Brazil	5.61	1.15	6.45
Russia	6.50	1.10	7.14
India	12.41	0.61	7.54
South Africa	9.59	0.92	8.86
China	9.17	1.06	9.74

Sources: IEA 2016f, World Bank 2016.

Limitation of Methodology

Devising a performance metric that allows for representative comparison of industrial energy intensity is inherently problematic. Several methodological approaches could be used, each with distinct advantages and disadvantages. One basic approach would be to compare a measure of a country's energy intensity using total final industrial consumption divided by industrial GDP. This approach is appealing in its simplicity but has clear drawbacks. High energy intensity does not necessarily correspond with wastefulness but depends on the structure of a country's industrial sector and the mix of individual industries within it. This approach does not account for structural differences, and it disadvantages countries with high-consuming, low-value industries.

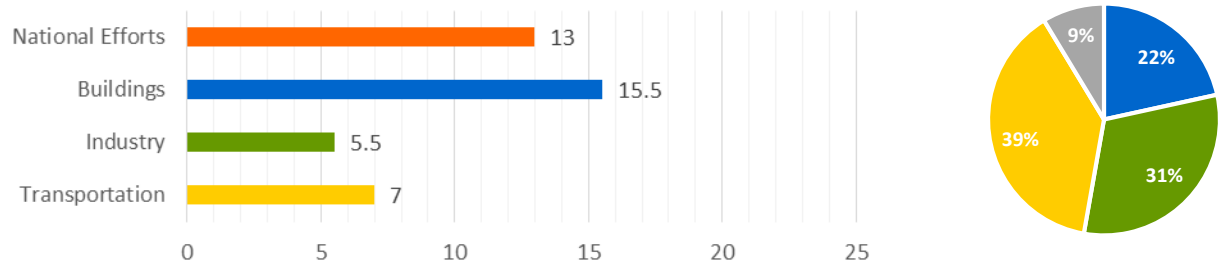
A different approach could instead compare the change in energy intensity over a given period of time. This approach has some advantages. Evaluating progress over time reduces the need to account for structural differences. Additionally, data are more readily available from centralized sources, and the methodology is clear and easy to understand. On the other hand this approach is sensitive to the time period analyzed and other externalities that may be difficult to pinpoint. For example, this method does not account for energy efficiency investments made prior to the baseline year; this could disadvantage countries that invested in efficiency early. Changes in intensity could also result from other factors unrelated to efficiency improvements, such as structural shifts among industries or the effects of an economy-wide recession or a downturn in a specific industry due to market effects.

We chose to compare a weighted measure of energy intensity for each country based on the intensity of the individual industries that make up its industrial sector. Our method therefore accounts for structural differences across countries, and in our professional judgment provides a more meaningful analysis than other options. However this approach is more complicated and requires us to make many assumptions, especially when data are limited. For example, the assumption that relative intensities among industrial subgroups in other countries follow US patterns may not hold true for every country, but allows us to estimate intensity when faced with a lack of or inconsistent data. We thus urge caution in interpreting the rankings resulting from this metric.

Appendix B. Country Summaries

Appendix B consists of one-page summaries of the evaluated countries' performance on *The 2016 International Energy Efficiency Scorecard.* These summaries highlight the area of strongest performance as well as areas that need improvement for each country. Appendix C presents a more detailed set of recommendations for the United States.

AUSTRALIA, #16



The bars show ACEEE scores for energy efficiency. The pie chart shows 2013 end-use energy shares of buildings, industry, transportation, and other sectors.

Coming in 16th, Australia earned a total score of 41 points in 2016, performing just slightly better than Russia and Indonesia.

Australia was strongest in buildings energy efficiency compared to other sections, due to its fairly comprehensive building codes, building labeling program, and appliance and equipment labeling program. Since 2000 its strategy to reduce GHGs from buildings has included mandatory energy codes for new buildings. These requirements cover the residential and commercial sectors and include a wide-ranging set of technical elements. The state of Tasmania also has mandatory codes in place for the renovation of existing commercial and residential buildings.

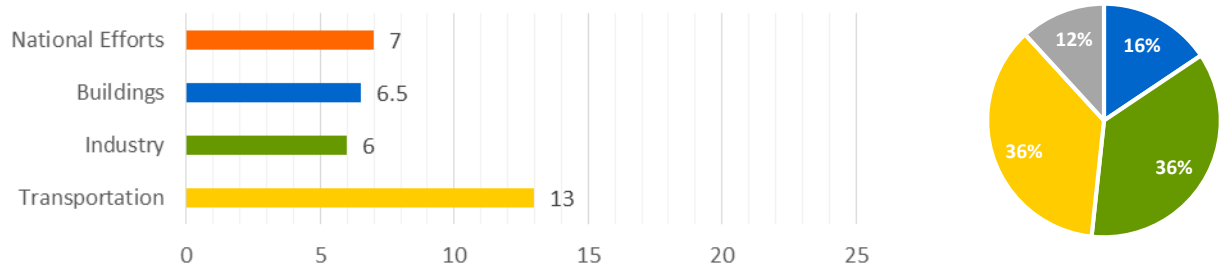
Australia scored in the middle of the pack on the national efforts front, coming in 13th place. The Australian government aims to increase energy productivity by 40% by 2030, and it released a National Energy Productivity Plan in 2015 to highlight the key strategies that it will use to achieve this goal including improving the national construction code, improving the overall energy-use ratings of buildings, and increasing the efficiency of equipment.

Areas for Improvement

Australia ranked second from the bottom in the transportation section. It had fuel economy standards for passenger vehicles in place, but failed to extend them when they expired in 2010. The country also does not currently have fuel economy standards for heavy-duty trucks. In addition, Australia's percentage of public transit use is low (approximately 12%), and it invests only about $0.50 in rail facilities for every dollar spent on road construction and maintenance.

Australia scored equally poorly for its industrial energy efficiency efforts. CHP is not a priority for the country, and as of 2014 the government had shut down its Energy Efficiency Opportunities (EEO) program, in an effort to reduce costs for businesses and abide by the current administration's deregulation agenda. The EEO aimed to improve the identification and evaluation of energy efficiency opportunities by large energy-using corporations, and as a result encourage implementation of cost-effective energy efficiency opportunities.

BRAZIL, #22



The bars show ACEEE scores for energy efficiency. The pie chart shows 2013 end-use energy shares of buildings, industry, transportation, and other sectors.

Brazil ranked 22nd with 32.5 points out of 100. Energy policy in Brazil largely emphasizes renewable-energy production especially in the electricity and transportation sectors. This focus on energy production leaves a great deal of energy efficiency potential untapped.

Brazil performed best in the transportation section of this year's *Scorecard*, where it ranked 8th out of 23 countries. The country has good passenger-vehicle fuel economy standards in place, but to date these standards are still voluntary although there are strong incentives for auto manufacturers to comply. Brazil is also considering the implementation of heavy-duty standards. The Brazilian government has shown commitment to financing more-efficient modes of transportation. The Brazilian National Development Bank has increased funding for the construction of new railway lines and the expansion of the current network to improve freight efficiency; it also plans to build a high-speed rail line connecting São Paulo and Rio de Janeiro.

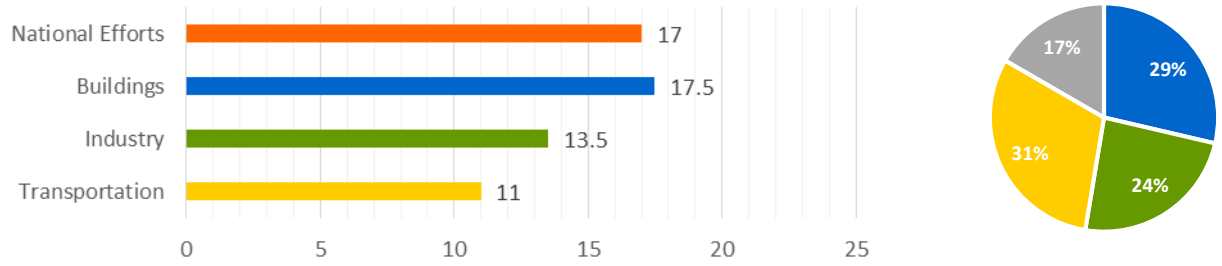
The Brazilian government has established a National Plan on Climate Change (PNMC), which contains some provisions related to the establishment of a national energy efficiency action plan. The government has not implemented a national energy savings policy, but a proposed national action plan would aim to reduce electricity consumption by 10%, saving up to 106 terawatt-hours (TWh) per year by 2030. The country has also submitted an INDC plan to the UNFCCC, which outlines a commitment to reduce GHGs by 37% from 2005 levels by 2025. The government hopes to achieve some of these goals through programs implemented by PROCEL, a national energy conservation scheme that has saved Brazil more than 92 billion kilowatt-hours (kWh) since 1986. The Brazilian Programme for Labelling (PBE) and the Selo Procel define minimum performance levels for significant energy-consuming equipment such as refrigerators, ceiling fans, lightbulbs, and residential air-conditioning systems.

Areas for Improvement

Brazil has no mandatory residential or commercial building code and has only a limited number of appliance and equipment standards. Many countries have realized significant energy savings by implementing building energy efficiency policies, including Australia, France, and the United Kingdom. The United States has saved considerable energy through robust appliance standards. Brazil thus has ample models on which to draw to improve energy efficiency in buildings.

Brazil was fourth from the bottom in the industrial section and would benefit from public–private voluntary agreements for energy efficiency and requirements for plant energy managers or periodic energy audits. Less than 1% of electricity in its industrial sector is generated through CHP.

CANADA, #10



The bars show ACEEE scores for energy efficiency. The pie chart shows 2013 end-use energy shares of buildings, industry, transportation, and other sectors.

Standing in 10th place, Canada earned 59 points and ranked just under Spain, South Korea, and the United States.

Canada was strongest in buildings energy efficiency due in part to its comprehensive appliance and equipment standards, which cover a large number of products on the market, and its mandatory EnerGuide labeling program, modeled after the EnergyGuide label in the United States. Canada has taken steps to improve the benchmarking and labeling of energy use in its buildings through a new benchmarking portfolio manager that rates buildings' energy performance against similar buildings.

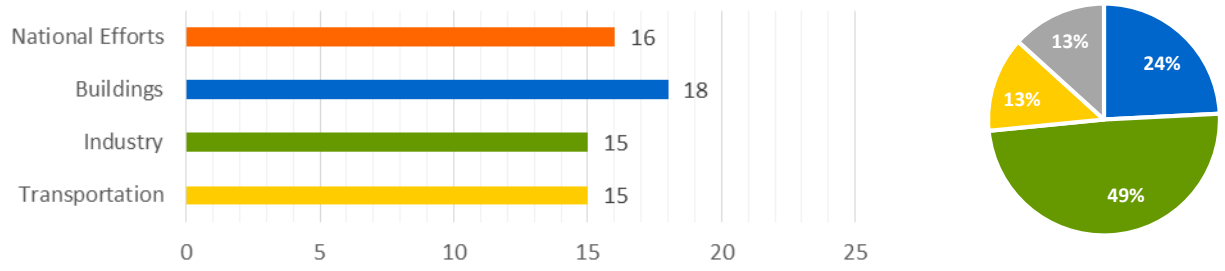
Canada also did well in the national efforts category. The country submitted an INDC plan to the UNFCCC that intends to achieve an economy-wide target to reduce GHG emissions by 30% from 2005 levels by 2030. In 2008 Canadian provinces and territories committed to achieving a 20% increase in energy efficiency by 2020 through improvements to building codes, broader regulation of energy-consuming products, the establishment of green building policies for new government-funded facilities, support for home energy audits, and retrofit assistance. National tax incentives exist in multiple sectors to help reach efficiency targets, but government investment in energy efficiency remains low, and investment in R&D is only moderate.

Areas for Improvement

Canada scored low on industrial efficiency and would benefit from establishing a mandate for plant energy managers and mandatory energy audits. Our research indicated that just 5% of the electricity consumed by the industrial sector is generated by CHP, and only about 3% of manufacturing GDP is spent on manufacturing R&D. Other countries, most notably Japan, have improved energy savings in this sector with increased investment in industrial R&D and requirements for energy managers and audits. It is important to note however that a robust network of voluntary partnerships exists between the government and manufacturers.

Canada would also benefit from energy efficiency improvements to its transportation sector. Like the United States, Canada is a car-heavy economy, which means that very little daily travel occurs on more-efficient forms of transport. Only 2.9% of travel occurs on public transport in Canada, and as a result the country has a high number of VMT in personal vehicles per capita.

CHINA, #6



The bars show ACEEE scores for energy efficiency. The pie chart shows 2013 end-use energy shares of buildings, industry, transportation, and other sectors.

China claimed the 6th spot with a total score of 64, ranking just 2 spots higher than the United States.

China ranked third (tied with France), behind Germany and the United States, in the buildings section of the *Scorecard*. Both residential and commercial buildings in urban areas are subject to mandatory building codes. However China still has room for improvement in compliance with and enforcement of its building codes, which have historically been stronger at the design stage than at the construction stage. China has also adopted appliance and equipment standards for a relatively large number of products and requires energy efficiency labeling for some building types.

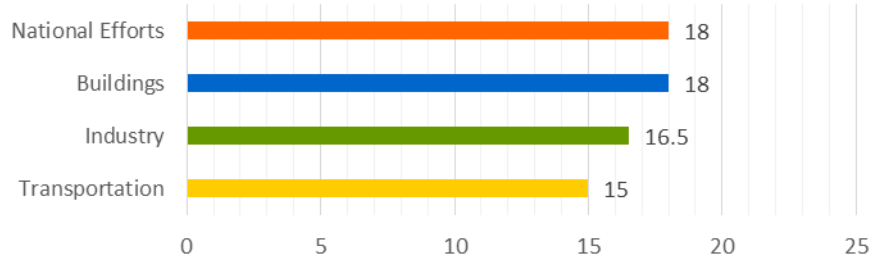
China scored well in transportation efficiency, tying with France for fourth place. China has mandatory fuel economy standards for passenger vehicles, which call for a fleet-wide average of 47.7 mpg by 2025. Standards for heavy-duty vehicles also exist and aim to achieve a 14% reduction in heavy-vehicle energy consumption over the lifetime of the standards. The number of VMT per person is very low, and the percentage of trips taken by public transit is higher than in any other country. This is largely due to the fact that personal-vehicle ownership is low. In June 2012 China enacted an energy savings plan and a new development plan for the auto industry, aimed at producing energy-efficient vehicles. Under the plan the country is targeting 5 million plug-in hybrid and electric vehicles by 2020.

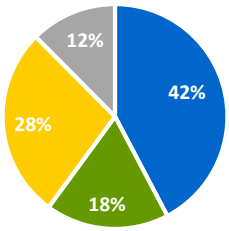
Areas for Improvement

The energy intensity of China's industrial sector is among the highest of the countries analyzed, and there is little investment in R&D for industrial manufacturing. China also has a relatively low proportion of energy generated by CHP and is estimated to have tapped into less than 20% of its industrial CHP potential. The National Development and Reform Commission (NDRC) has set a goal of 200 GW of CHP by 2020, but no accompanying incentives are in place to encourage the increased deployment of CHP.

Additional room for improvement exists in the national efforts category, particularly with regard to spending on energy efficiency R&D and improving the efficiency of the country's thermal power plant stock.

FRANCE, #4





The bars show ACEEE scores for energy efficiency. The pie chart shows 2013 end-use energy shares of buildings, industry, transportation, and other sectors.

France claimed 4th place with a score of 67.5 points, just 1 point behind Italy and Japan. France was 6 points behind the top scorer, Germany.

France came in 3rd place in the buildings section with a score of 18 points. The country's Energy Efficiency Action Plans outline aggressive policies to increase the number of low-energy buildings and also commits to the deep renovation of 500,000 dwellings per year. France also has mandatory and comprehensive performance-based building codes in place for both residential and commercial buildings, established through the *Réglementation thermique* in 2012. France updated its national building regulations in 2005 and requires construction projects to comply with maximum primary energy-consumption standards.

Additionally, France did well in both the national efforts and the transportation sections, largely due to its participation in EU actions. Under the European Union's Energy Efficiency Directive (2012/27/EU), France has made a major commitment to reduce energy consumption by more than 17% by 2020. Similarly the country participates in the European Union's stringent fuel economy standards, which call for a fleet-wide average of 56.9 mpg by 2025.

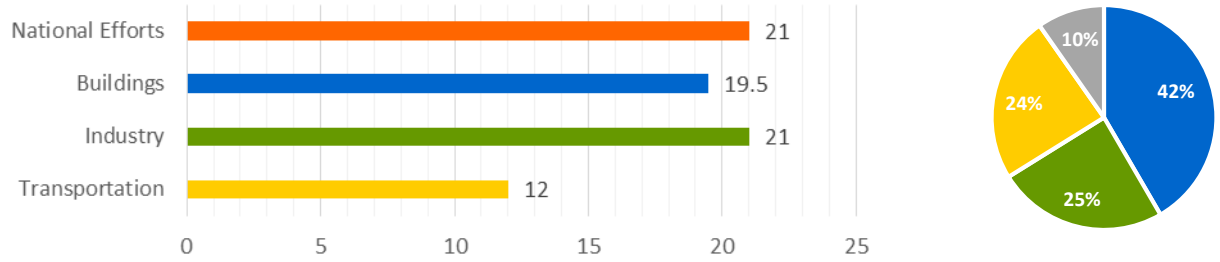
Areas for Improvement

Despite having many exemplary energy efficiency policies in the major end-use sectors of energy, France falls behind in the industrial sector. France has a low percentage of installed capacity from CHP and has no incentives or targets in place to increase CHP's share of generated power. The numerous incentives and policies of both Germany and Italy could serve as models for CHP deployment.

France could improve on several aspects of the transportation sector. Despite coming in 4th in this category, France scored a total of only 15 points out of a possible 25. The energy intensity of freight transport in France is high, and investment in rail versus roads is low. France would benefit from measures to increase the overall efficiency of the freight transportation system to reduce energy intensity.

Overall France must continue to implement the ambitious policies and targets set out in its national objectives and in EU directives in order to truly achieve the intended energy savings.

GERMANY, #1



The bars show ACEEE scores for energy efficiency. The pie chart shows 2013 end-use energy shares of buildings, industry, transportation, and other sectors.

Germany scored 73.5 out of 100 points in 2016, maintaining its position as the top-ranking country on the *Scorecard*. German policymakers have implemented a comprehensive energy strategy known as *Energiewende*, helping the country to become one of the most energy-efficient economies. The country has set a target of a 20% reduction in primary energy consumption by 2020 and a 50% reduction by 2050, compared to 2008 levels. To meet this ambitious goal the German government has implemented a comprehensive set of complementary policies and incentives funded by the KfW Development Bank. As a result Germany ranks first in the national efforts section.

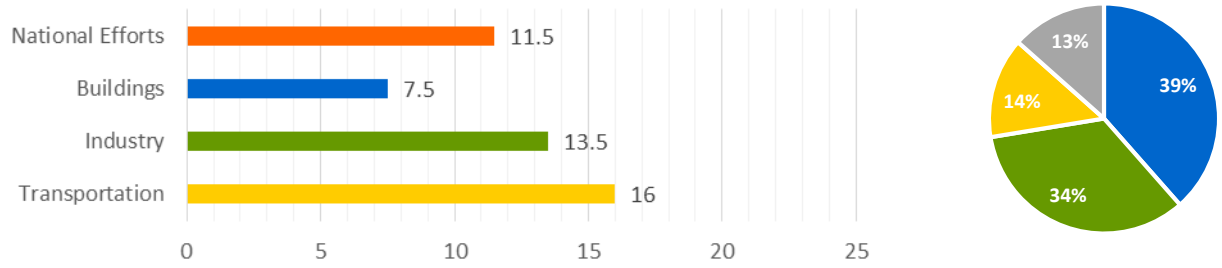
Germany also came in first in the industrial section of the 2016 analysis. The energy intensity of Germany's industrial sector is relatively low compared with that of other countries, with the majority of energy used in the chemical and iron and steel industries. A voluntary agreement between German industry and the federal government to reduce CO_2 emissions has been in place since 1995 (IEA 2013). Updates in 2012 set targets for annual reductions in energy intensity until 2022 (IIP 2016a). Germany also has a target of obtaining 25% of its electricity generation from CHP by 2020. However, given Germany's recent renewables-capacity expansion in recent years, the new CHP law of 2016 (which has been passed by the German parliament but is awaiting European Commission approval) changes this target to 25% of net controllable electricity generation, which excludes wind-generated energy and photovoltaics. The CHP Act (KWK-G) provides investment support in the form of a feed-in tariff.

Areas for Improvement

Germany claimed the top spot in buildings efficiency thanks largely to its national Energy Saving Ordinance for buildings in 2002, which set energy performance requirements for new buildings and existing buildings undergoing major renovations. Nevertheless plenty of untapped efficiency potential still remains, particularly in the area of appliance standards, which could help reduce the energy intensity of both commercial and residential buildings.

Likewise the transportation sector, for which Germany scored only 12 out of a possible 25 points, provides some energy efficiency opportunities. Outside of the European Union's passenger-vehicle standards few efforts have been made to reduce energy consumption in this sector. While public transit is widely available, Germany's status as an auto-manufacturing powerhouse has led to the use of personal vehicles as the primary mode of transport and little government interest in investing in rail or other public-transit facilities.

INDIA, #14



The bars show ACEEE scores for energy efficiency. The pie chart shows 2013 end-use energy shares of buildings, industry, transportation, and other sectors.

Coming in 14th, India scored a total of 48.5 points.

India is strongest in transportation energy efficiency. It has a far lower number of passenger miles traveled per capita than any other country analyzed. Even with no fuel economy standards for passenger vehicles, India ranks third in passenger-vehicle fuel economy. More than 65% of passenger trips made in India utilize public transit, with only a moderate level of government investment in rail versus roads. However it is important to note that India's successes in the transportation sector have more to do with the status of its economy than with its efforts to reduce energy consumption.

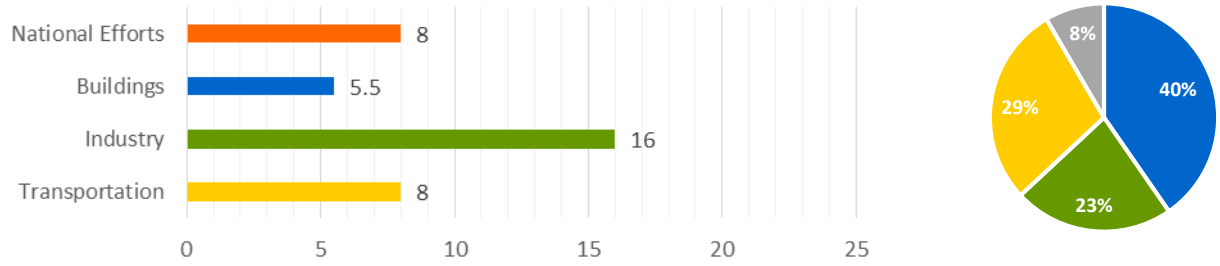
Areas for Improvement

India ranked 15th in national efforts on energy efficiency, and there are many opportunities to improve in this category. The operational efficiency of thermal power plants in India is the lowest of any country analyzed, largely due to an aging power plant fleet. India would benefit from increasing its level of government and utility investment in energy efficiency in addition to spending on efficiency R&D, if efficiency is truly a priority for the country.

India's buildings sector also shows room for improvement, as India was sixth from the bottom in this section. The country could further bolster its voluntary energy codes for both residential and commercial buildings by adding requirements for existing residential and commercial buildings. The government could also focus on making building codes mandatory for new buildings, as much of India's building stock has yet to be developed. Further, India has appliance and equipment standards for just seven products; its efficiency in the buildings sector could improve significantly if it expanded its efforts in this area.

Last, the industrial sector also offers numerous opportunities for energy savings. Establishing a program that creates voluntary agreements between manufacturers and the government would kick-start some of these energy savings by holding manufacturers accountable for their energy consumption.

INDONESIA, #18



The bars show ACEEE scores for energy efficiency. The pie chart shows 2013 end-use energy shares of buildings, industry, transportation, and other sectors.

Coming in 18th, Indonesia scored 37.5 points and ranked higher than Mexico, Thailand, South Africa, Brazil, and Saudi Arabia. Indonesia is strongest in industrial energy efficiency, with excellent policies in place on energy management for large energy consumers. Mandates for energy managers, energy audits in large industries, encouragement of energy management standards (ISO 50001), and low energy intensity ranked Indonesia (alongside China and the Netherlands) in seventh place in our industrial-sector rankings. The country can further improve its industrial energy efficiency by implementing performance standards for motors and building on its existing voluntary energy efficiency programs with manufacturers.

Indonesia also scored full points for its reduction of energy intensity. Intensity of total primary energy consumption decreased by 31% between 2000 and 2013. Indonesia's Energy Law, passed in 2007, set the tone for a new framework in energy policy. The law not only specifies pathways for energy conservation but also includes a goal in its National Master Plan for Energy Conservation (RIKEN) to reduce energy intensity by 1% annually until 2025. Indonesia was second best in the category of VMT per capita for passenger vehicles.

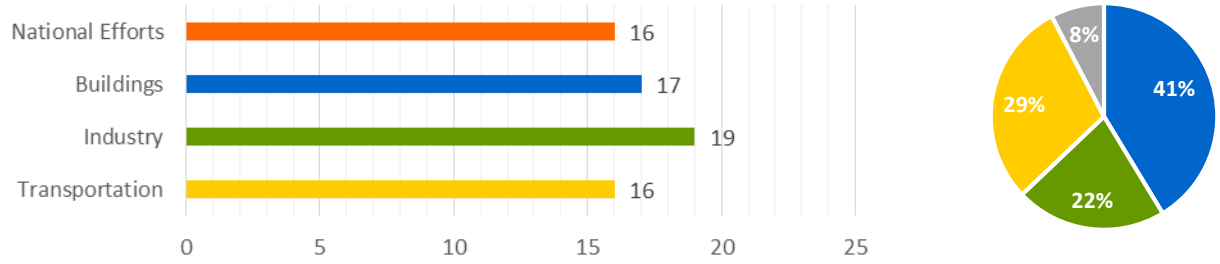
Areas for Improvement

Overall Indonesia's scores were low in the national efforts, buildings, and transportation categories. With few incentives available for private investment in energy efficiency, its ESCO market has seen negligible improvement since the first state-owned ESCO was established in 1986. Policies such as tax incentives and government loans for energy efficiency programs could encourage the energy efficiency market in Indonesia, which is estimated to have the highest potential in Southeast Asia.

Indonesia can greatly improve in the area of mandatory performance standards and energy labeling schemes for appliances. It currently has just 2 or fewer appliance groups with mandatory standards or labels, while the top-performing countries have standards for over 50 appliance groups and categorical labels for over 15 appliance groups. In the buildings sector Indonesia has no policies for energy performance of existing buildings and retrofits, while the highest-scoring countries have strong energy codes at the national level for residential and commercial buildings, both new construction and existing buildings. Indonesia would also benefit by establishing a national policy for building energy information disclosure, as it currently has none.

As demand for mobility increases, the country must plan ahead for meeting this demand by improving public transportation, regulating fuel economy standards for light-duty vehicles, and investing in overall R&D for efficient systems in all economic sectors.

ITALY, #2



The bars show ACEEE scores for energy efficiency. The pie chart shows 2013 end-use energy shares of buildings, industry, transportation, and other sectors.

Tied for 2nd place with Japan, Italy scored 68.5 out of 100 possible points, 5 points behind Germany.

In the transportation sector Italy tied with India and Japan for 1st place with 16 points. Italy participates in the European Union's vehicle standards program and aims to achieve a fleet-wide average of 56.9 mpg by 2025. Italy's average on-road fuel economy for passenger vehicles is impressive at 38.6 mpg. VMT per capita is also lower in Italy than in any other European country, and Italy has a high ratio of investment in rail transit to investment in roads.

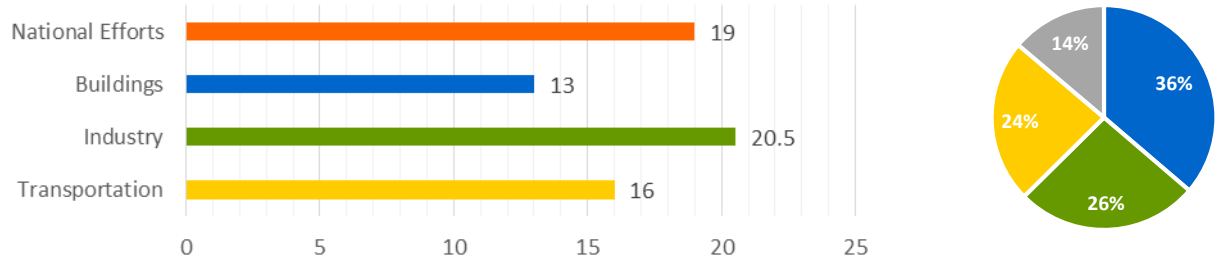
Italy has shown a commitment to energy efficiency in its industrial sector by establishing energy savings targets, requiring plant energy managers to meet these targets, and mandating periodic energy audits. A market-based energy efficiency certificate scheme (using white certificates) is the key tool for achieving the industrial sector's savings goal, set at 5.1 Mtoe. Italy is among the countries with the largest shares of installed CHP capacity due in part to its policies to encourage CHP deployment.

Italy's policies in the buildings sector are also among the best practices highlighted in this report. Several initiatives exist at the national level to support an increased rate of renovation, including a new incentive program, Conto Termico, to provide incentives for retrofits and energy efficiency improvements in residential and public buildings. Certain regional building codes also have mandatory energy efficiency requirements for renovations that must be met by a certain date.

Areas for Improvement

The greatest area in which Italy could improve is in the national efforts section. Although the country is committed to a national energy savings target under the European Union's Energy Efficiency Directive (2012/27/EU) to reduce energy consumption by 15 Mtoe by 2020, Italy could make more of a commitment by increasing spending on energy efficiency programs and R&D. The country saw only a 9% reduction in overall energy intensity between 2000 and 2013.

JAPAN, #2



The bars show ACEEE scores for energy efficiency. The pie chart shows 2013 end-use energy shares of buildings, industry, transportation, and other sectors.

Coming in 2nd, Japan tied with Italy with a score of 68.5 out of a possible 100 points.

Japan earned second place in the national efforts category. With a significant reduction in energy intensity between 2000 and 2013, strong energy-saving goals, and one of the most efficient thermoelectric power systems, Japan is exemplary in leading energy efficiency efforts.

Japan also did exceedingly well in the industry section of our analysis. Japan has developed a mix of regulatory measures, voluntary actions, and financial incentives to encourage energy efficiency in industry. The Act Concerning the Rational Use of Energy introduced mandatory energy efficiency requirements for designated industries in 1978 and continues to serve as the foundation of Japan's energy efficiency policy. It requires companies to appoint an energy manager and report on the status of energy consumption every year, and includes a benchmarking system obligating businesses to achieve specific medium-term (2015) and long-term (2020) energy efficiency targets. The country supports these requirements with a tax incentive scheme including a special depreciation rate for all businesses investing in specified energy conservation and efficient equipment.

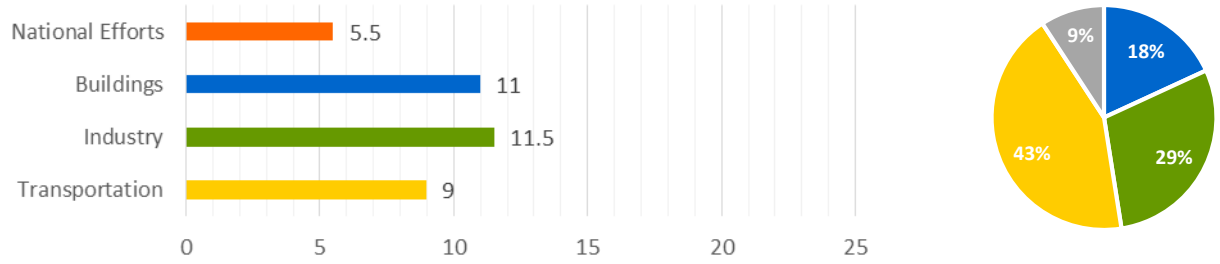
Japan scored well in the transportation category, tying for first place with Italy and India. Japan has set ambitious fuel economy standards for passenger vehicles (45.9 mpg by 2025), and average on-road fuel economy is equally impressive at 45.2 mpg. Japan established the first fuel economy program for heavy-duty vehicles in 2005 and is one of only four countries in our roster of evaluated countries to have done so to date.

Areas for Improvement

The largest area for improvement in Japan is in the buildings sector. Japan ranked 13th in the buildings section of our analysis due to its uneven residential and commercial building codes and a complete lack of building energy labeling initiatives. Japan also has no comprehensive building-retrofit policy and requires owners or developers to submit an energy savings plan only when large renovations are undertaken. Japan has a great opportunity to increase the energy efficiency of its buildings by strengthening building codes, improving code compliance, and implementing mandatory labeling programs for all buildings.

While Japan scored well on industrial energy efficiency, and commitment to efficiency in its industrial sector is strong, the percentage of CHP in Japan's power capacity is very low. However the government offers support to help encourage a greater contribution from CHP. The country's Ministry of Economy, Trade, and Industry (METI) has studied barriers to expanded CHP deployment and established an office focused on promoting CHP in Japan, actions that could be further supported by a comprehensive package of incentives. These efforts can help Japan narrow the gap with Germany, the top-ranking country.

MEXICO, #19



The bars show ACEEE scores for energy efficiency. The pie chart shows 2013 end-use energy shares of buildings, industry, transportation, and other sectors.

Mexico ranked 19th with 37 points, above Thailand, South Africa, Brazil, and Saudi Arabia.

Of the 4 categories Mexico was strongest on energy efficiency in buildings, ranking 16th. Mexico has also established appliance and equipment standards for approximately 30 products and has mandatory labeling for 13 products. In the area of building codes, Mexico has requirements in place for commercial buildings but does very little to regulate construction in residential or existing buildings.

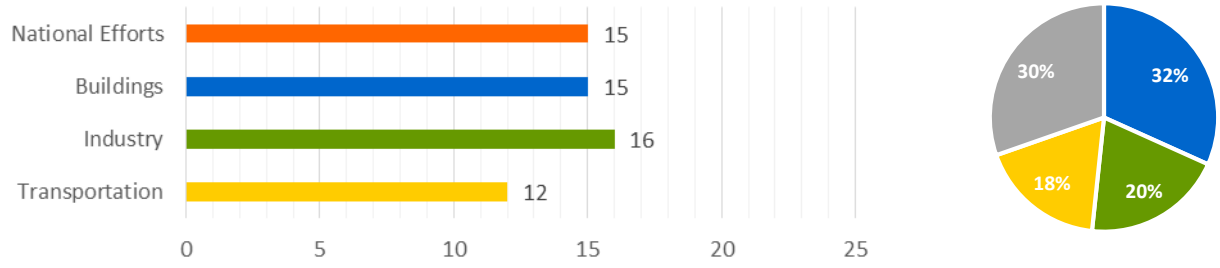
Areas for Improvement

Mexico has submitted a GHG reduction plan to the UNFCCC, but would benefit from establishing a mandatory national energy savings goal along with a comprehensive implementation plan. It could also increase its level of spending for energy efficiency measures and energy efficiency R&D. Many countries have achieved savings from national policies to help spur greater efficiency and innovation, including France, Spain, and China, and their initiatives can provide a framework for others.

There is also room for improvement in Mexico's industrial sector. Mexico has no voluntary energy performance agreement program or incentives for businesses in the manufacturing sector to improve energy efficiency. It has no law or regulation requiring industrial facilities to employ a plant energy manager, and it does not require periodic energy audits. Mexico could follow the examples of several countries, including India, Japan, and China, that have increased industrial efficiency by establishing these types of policies.

Within the transportation sector Mexico has passenger-vehicle fuel economy standards in place, but could benefit from increasing the stringency of the program and adding a heavy-duty component. Freight system efficiency is another area for potential improvement, as Mexico's energy use per ton-mile traveled is high.

NETHERLANDS, #11



The bars show ACEEE scores for energy efficiency. The pie chart shows 2013 end-use energy shares of buildings, industry, transportation, and other sectors.

The Netherlands ranked 11th on energy efficiency in our list of countries with a score of 58, just below Canada and well above Poland.

Under the EU Energy Efficiency Directive (2012/27/EU), the Netherlands is obliged to revise and submit its National Energy Efficiency Action Plan (NEEAP) every three years. The Energy Agreement for Sustainable Growth aims to achieve annual savings of 1.5% in final energy consumption, and the country expects to meet the target comfortably. The Netherlands also ranked among the top scorers for the efficiency of its thermal power plants.

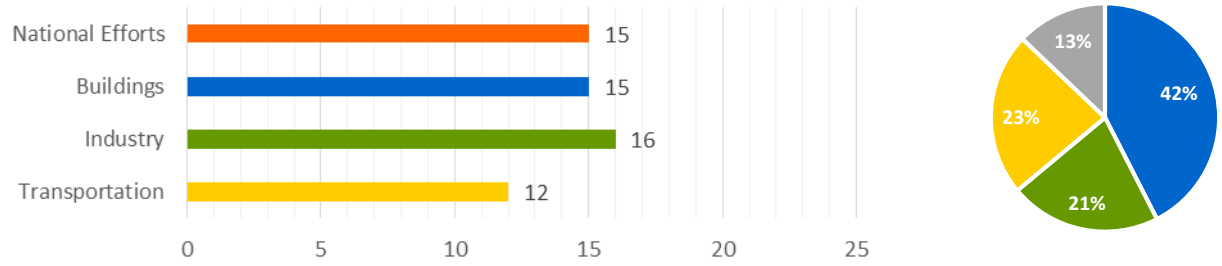
Of the four sections the Netherlands performed the best in the industrial section, in which it ranked seventh. Energy intensity of the industrial sector is relatively low. The Netherlands has consistently demonstrated leadership since 1992 with its Long-Term Agreements (LTAs) between government and industry groups, aimed at promoting energy savings. The LTAs also direct industries consuming 80% of energy in the sector to draw up energy efficiency plans every four years, report on measures every year, and submit energy audits. All large enterprises not covered by the LTAs are also mandated to undergo energy audits.

The Netherlands also scored full points for the share represented by CHP systems in total installed power capacity. At 41%, its share of CHP in installed power capacity is among the highest of all the countries we ranked, second only to Russia, whose CHP share stood at 59% in 2013. In the transportation sector the Netherlands is governed by EU standards, which call for a fleet average of 56.9 mpg for light-duty vehicles by 2025, higher than the standards of other countries studied in this report. Like other EU countries the Netherlands currently has 21 appliance groups covered by mandatory MEPS and 15 appliance groups covered by mandatory labels.

Areas for Improvement

Although Dutch government programs strongly support energy efficiency, there is good room for improvement in the ESCOs industry, whose potential is estimated at 30 million euros per year. Key barriers include a lack of exemplary projects and lack of awareness of the concept. The European Union including the Netherlands can benefit greatly by expanding the number of appliance groups covered under standards. The top-scoring countries have standards for over 50 appliance groups. Of the 4 sectors analyzed the Netherlands performed the lowest in the transportation sector, scoring only 12 of the possible 25 points. The Netherlands would achieve energy savings by improving its investment in rail versus road transit and adopting fuel economy standards for freight trucks.

POLAND, #12



The bars show ACEEE scores for energy efficiency. The pie chart shows 2013 end-use energy shares of buildings, industry, transportation, and other sectors.

Earning 53.5 points, Poland ranked in 12th place, well below the Netherlands and above Taiwan.

Between 2000 and 2013 Poland's GDP improved by 57%, while its primary energy consumption increased by only 16%. Thus Poland's improvement in energy intensity was one of the best among the 23 countries evaluated. Poland performed equally well in both the national efforts and the buildings efficiency categories. Its strength lies in its national leadership in following the EU Directive 2012/27/EU. Poland aims to achieve primary energy savings of 13.6 Mtoe between 2010 and 2020, compared to its primary energy consumption in 2020, forecast at 110 Mtoe.

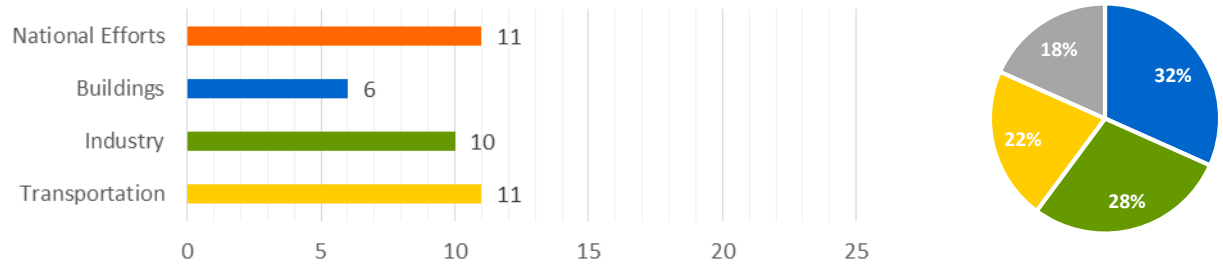
Poland scored full points for providing tax incentives and loans for energy efficiency programs and for its building and appliance energy labeling, mandatory energy audits in industry, performance standards for motors, and fuel economy standards for light-duty vehicles. Poland also scored higher than other countries on its mandatory energy codes for existing residential and nonresidential buildings and renovations. Poland's ESCOs market benefits from government regulation in favor of energy efficiency. The current size of the country's ESCOs market is estimated at about $13 million in total value of contracts. Poland scored 2 of the possible 3 points for energy intensity of freight transport (energy consumed per distance traveled) and ranked fourth highest on this metric.

Areas for Improvement

To spur more activity in industry the Polish government can encourage voluntary agreements with manufacturers to improve energy efficiency. Implementing a mandate for energy managers in enterprises with high energy consumption would also improve Poland's standing in the industrial sector. The efficiency of Poland's fossil fuel electricity plants, including distribution losses, is sixth from the bottom. In the area of building codes Poland can improve by outlining how code compliance is enforced. The top-performing countries on this metric impose penalties for noncompliance.

Poland scored about average on efficiency in the transportation sector. Overall the use of passenger cars for personal transport is 6th highest on the list, with 3,783 VMT per capita every year. Its ratio of investment in rail versus road transportation is one of the lowest three on the list. Poland can capture greater energy savings by implementing the plans outlined in the NEEAP to improve rail transport and adopt intelligent transport systems. In addition, Poland can benefit from setting fuel economy standards for heavy-duty trucks.

RUSSIA, #17



The bars show ACEEE scores for energy efficiency. The pie chart shows 2013 end-use energy shares of buildings, industry, transportation, and other sectors.

Coming in 17th, Russia scored 38 points, ranking just below Australia and above Indonesia and Mexico.

Of the 4 categories Russia is strongest on transportation efficiency, ranking 14th and scoring just 1 point less than the United States. The lower overall energy intensity of Russia's transportation sector is due to fewer VMT per capita and Russia's strong investment in rail transit. This investment in rail brings energy efficiency benefits in the form of low energy intensity of freight transport. Russia has the lowest energy intensity of freight transport of any country analyzed.

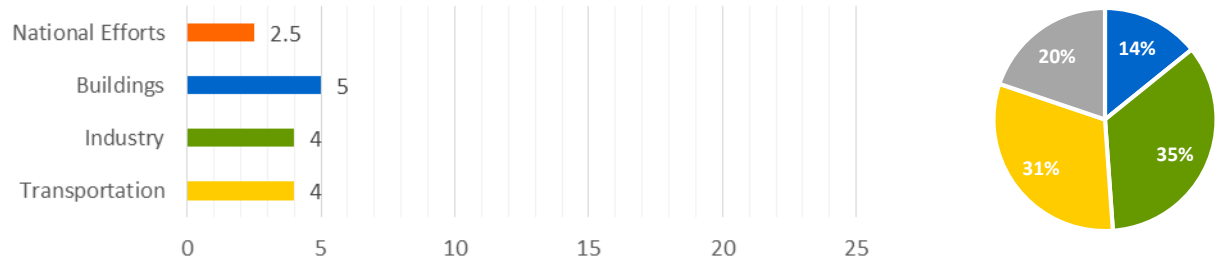
Likewise Russia has strengths in the industrial sector. The energy intensity of Russia's industrial sector is moderately high, but a significant portion of the electricity consumed by the industrial sector is generated by CHP, which improves overall efficiency. Russia requires periodic energy audits of its manufacturing facilities and has agreements and incentives in place between governments and businesses to encourage and promote energy efficiency.

Areas for Improvement

In the buildings sector Russia was among the bottom five countries. Russia recently saw a significant rollback in its building energy codes, which made most of the energy efficiency requirements voluntary; only building envelope requirements are still mandatory. Furthermore appliance and equipment standards apply to only one product, the lowest number of products regulated by any country in our study. To increase its efficiency in buildings Russia would benefit from adopting the best practices demonstrated by countries such as Australia, France, and Germany.

Russia also has room to improve its national efforts. Thermal power plants in Russia are among the least efficient of any country, and improved federal programs for increasing investment in energy savings would help achieve greater efficiency overall.

SAUDI ARABIA, #23



The bars show ACEEE scores for energy efficiency. The pie chart shows 2013 end-use energy shares of buildings, industry, transportation, and other sectors.

Saudi Arabia scored 15.5 points and is at the bottom of the rankings.

Saudi Arabia's standing is due in part to poor scores and in part to lack of data. Information was not available for a number of metrics including spending on energy efficiency and energy efficiency R&D, fuel economy of light-duty vehicles, fuel economy standards for heavy-duty tractor trucks, freight transport per unit of economic activity, energy intensity of freight transport, and investment in rail transit versus roads. If more data were available, it is possible that Saudi Arabia would have performed better in our rankings.

The Saudi Energy Efficiency Center (SEEC), formed in 2010, aims to reduce energy consumption and achieve the lowest possible levels of energy intensity. In recent years the SEEC has stepped up efforts to formulate policies on building codes, appliance standards and labels, performance standards for motors, and energy audits in the industrial sector.

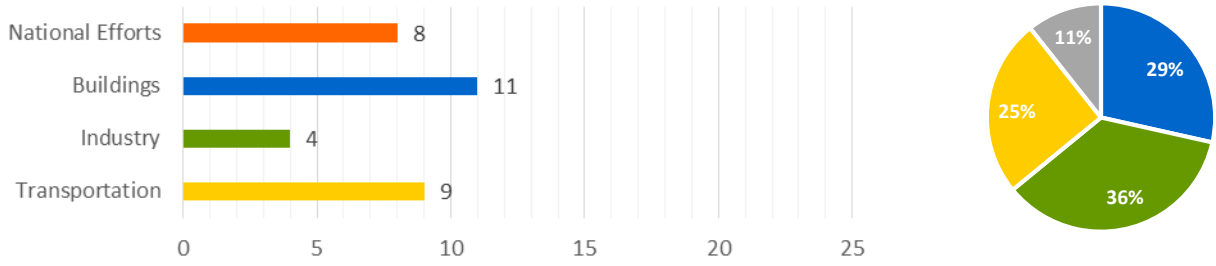
Areas of Improvement

Saudi Arabia would boost its ranking by greatly increasing the number of appliance groups covered by mandatory performance standards and labels. Saudi Arabia would also benefit from implementing a strong energy code for existing buildings as well as a policy to disclose the energy use of all buildings.

In the transportation sector Saudi Arabia's newly introduced fuel economy standards for light-duty vehicles are a promising step toward reducing fuel consumption, but could be strengthened above the currently required 40 mpg by 2025.

Efforts to improve energy management in industries currently exist; however implementing mandates for energy managers, audits, and EnMS would speed up this process. Entering into voluntary agreements with manufacturers to improve energy efficiency would demonstrate leadership on the part of the national government. In addition, outlining a mandatory national savings target would help Saudi Arabia make steady incremental progress in all economic sectors.

SOUTH AFRICA, #21



The bars show ACEEE scores for energy efficiency. The pie chart shows 2013 end-use energy shares of buildings, industry, transportation, and other sectors.

Placing 21st, South Africa scored 33 points and ranked above Brazil and Saudi Arabia.

South Africa scored the full 8 points in building energy codes for new residential and nonresidential buildings. The country also scored relatively well on energy intensity in residential and nonresidential buildings. In the transportation sector South Africa ranked seventh for on-road fuel economy of light-duty vehicles in 2012. The country was among the highest scorers for VMT by passenger cars, with 719 VMT per capita, which is lower than in most other countries. South Africa also earned the full score for investment in rail versus road transport. Information was not available for energy intensity of freight transportation.

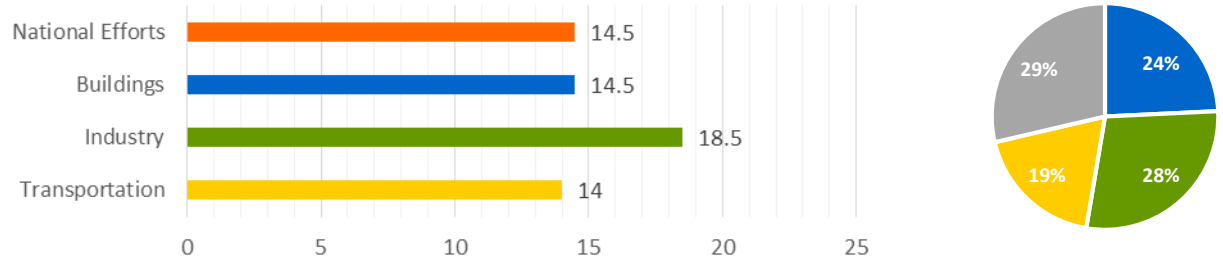
Areas for Improvement

There is huge potential for energy savings in the industrial sector, a category in which South Africa scored just 1 point. The energy intensity of South Africa's industry is the highest of all countries evaluated in this report. After rolling blackouts in 2008 the United Nations Industrial Development Organization (UNIDO) introduced the Industrial Energy Efficiency (IEE) Project in South Africa. As a result South Africa adopted the ISO 50001 as its national standard and currently also has an accreditation program for EnMS in industrial facilities. There is also a national tax incentive called Section 12L for energy efficiency savings. However there is no national policy that refers to the EnMS. South Africa would benefit greatly by overhauling its approach toward energy efficiency in industry. Exemplary policies include government-led programs for voluntary agreements with manufacturers to reduce energy use; mandating energy audits, EnMS, and energy managers in industries; performance standards for motors and pumps; and increasing investment in manufacturing R&D.

In the buildings sector South Africa could build on its existing policies by adopting performance standards and categorical labels for various appliances. Such standards help transform the market by preventing or discouraging less efficient appliances from entering the market. The country could also adopt labeling and disclosure practices for buildings. South Africa would also benefit from applying its building energy codes to existing buildings and retrofits.

Overall South Africa needs better leadership by the national government in focusing on energy efficiency across all economic sectors. The government must follow through and build on the energy efficiency potential identified in the INDC plan submitted to the UNFCCC in 2015.

SOUTH KOREA, #8



The bars show ACEEE scores for energy efficiency. The pie chart shows 2013 end-use energy shares of buildings, industry, transportation, and other sectors.

With a score of 61.5 points, South Korea tied with the United States for the 8th spot, followed by Canada, the Netherlands, and Poland.

Of the four categories South Korea scored well in the industrial category, ranking fifth. The Korean Energy Management Corporation, which implements energy efficiency programs in South Korea, provides financial support and tax credits for businesses that enter into voluntary agreements or invest in energy-saving technologies. In addition, the country requires energy audits at large manufacturing facilities every five years, and facilities in South Korea generate a fair amount of industrial electricity from CHP. All of these efforts help to lower overall energy use in the sector.

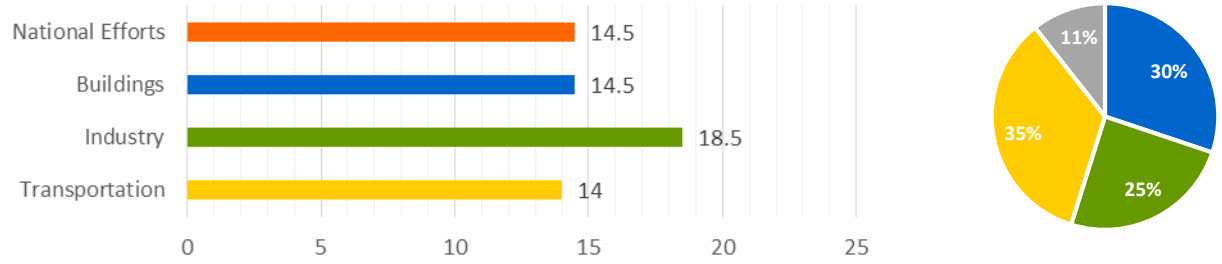
South Korea earned 14 points in the transportation section, ranking 6th. South Korea has some of the most stringent fuel economy standards in place for passenger vehicles, second only to EU requirements. Public transport appears to be a priority for the country, and approximately 42% of all passenger travel occurs on public transit.

Areas for Improvement

In terms of national efforts South Korea's Second National Energy Master Plan established a goal of a 13% reduction below the business-as-usual level by 2035, and implemented various regulations including a plan for an emissions-trading system. While some policies have already been established, a more coordinated strategy with a focus on energy efficiency would improve these policies under the second plan.

Building efficiency in South Korea also shows a need for improvement. While the country has mandatory residential and commercial building codes covering a broad range of technical components, it could still benefit from stronger building retrofit policies and the introduction of some sort of energy labeling system for both commercial and residential construction. Building energy efficiency is also particularly low in South Korea for both of these building groups.

SPAIN, #7



The bars show ACEEE scores for energy efficiency. The pie chart shows 2013 end-use energy shares of buildings, industry, transportation, and other sectors.

Coming in 7th, Spain earned a score of 62.

Spain tied with Canada for fifth in the buildings category. The country has strong mandatory building codes for both residential and commercial buildings, covering a broad range of technical elements. Furthermore Spain has renovation requirements in place for all buildings as part of its construction code. Spain is also one of just a handful of countries with a mandatory program for building labeling and building energy disclosure.

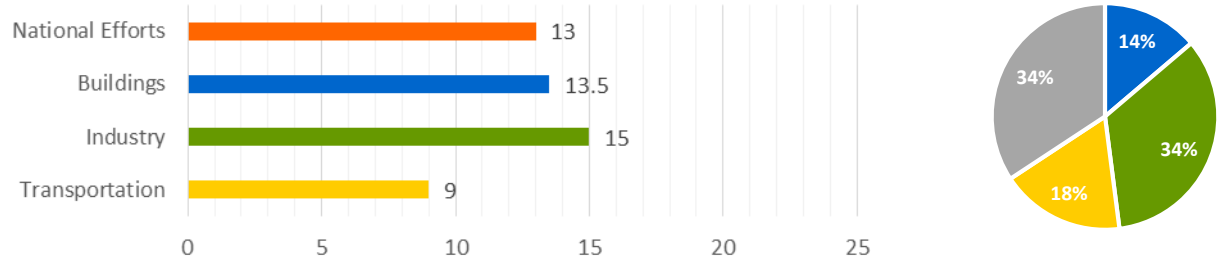
Spain ranked sixth in the national efforts category. Spain's mandatory energy savings goal under the EU Energy Efficiency Directive (2012/27/EU) targets energy savings of 20% by 2020. The Institute for the Diversification and Saving of Energy (IDEA), the national agency in charge of promoting energy efficiency, is implementing this national objective with a focus on improving final energy intensity by 2% each year from 2010 to 2020. Through this objective and its supporting policies Spain has experienced success in its national efforts.

Areas for Improvement

There is plenty of room for improvement in the industrial sector in Spain. Spain generates very little electricity from CHP and has no real CHP targets or incentives. The 2012–13 electricity market reform affected the CHP sector very negatively. CHP electricity generation at high-efficiency plants qualified for feed-in tariffs and premiums before the reform, but these were abolished in 2013.

Spain also has room for improvement in transportation. It scored well compared to other countries analyzed in this *Scorecard*, but could improve its energy intensity of freight transport and implement policies to spur greater use of public transportation. Spain can look to policies in other European countries such as Italy and Germany that have helped to reduce VMT, increase average fuel economy, and encourage the use of public transportation.

TAIWAN, #13



The bars show ACEEE scores for energy efficiency. The pie chart shows 2013 end-use energy shares of buildings, industry, transportation, and other sectors.

Coming in 13th place, Taiwan scored 51 points, ranking higher than India, Turkey, Australia, and Russia.

Of the four categories Taiwan performed the best in the industrial sector, where it stood at seventh place, above Spain, China, and the United States. The country earned full points for energy intensity of agriculture and scored reasonably well on the share of installed CHP capacity in its electricity generation. According to the Energy Administration Act energy audits, onsite energy managers, and energy consumption data reports are mandatory for large energy users in industry. Since 2011 Taiwan has also supported through pilot projects the adoption of ISO 50001 EnMS in the service sector.

Taiwan stood in 13th place for its national efforts toward energy efficiency. As a part of the framework for its Sustainable Energy Policy, Taiwan has a national goal to decrease energy intensity by 20% between 2005 and 2015, and expects to cut intensity in half by 2050 over 2005 levels. Taiwan has highly efficient fossil fuel thermal power plants, ranking 5th on our list of 23 countries. As a share of the country's GDP, Taiwan's $760 million ESCOs market is the largest of all countries evaluated in this report. Taiwan earned its lowest score in the transportation section; however it took the top spot for investment in rail versus road transit, investing 1.63 times more in rail systems compared to roads.

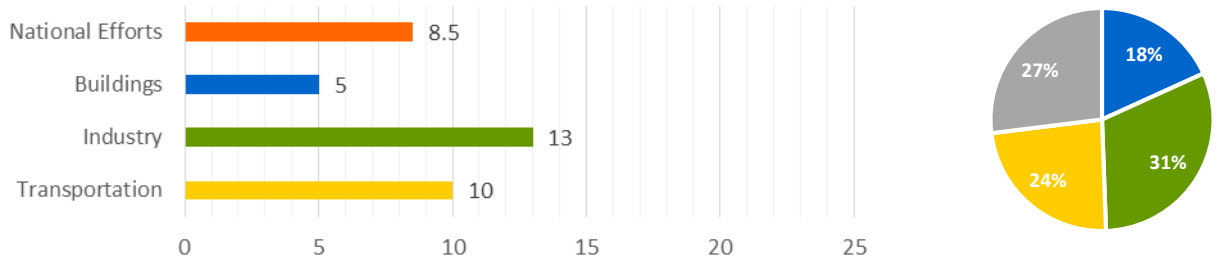
Areas for Improvement

Taiwan performed poorly on both average on-road fuel economy (24.2 mpg) and fuel economy standards for light-duty vehicles (22.25 mpg), while the top performance numbers are 45.2 mpg and 56.9 mpg, respectively. The country also currently has no fuel economy standards for heavy-duty trucks.

In the buildings sector Taiwan can gain from expanding its appliance standards program. Currently 15 groups of appliances are covered under MEPS, while top-scoring countries cover over 50 groups of appliances. Taiwan can also implement building energy labeling and disclosure policies to improve awareness among its citizens.

Introducing government-led voluntary efficiency programs in industries, improving performance standards for motors, and investing in industry R&D will propel Taiwan to become a leader in industry energy efficiency. Taiwan can benefit from increased government spending on energy efficiency programs in all sectors.

THAILAND, #20



The bars show ACEEE scores for energy efficiency. The pie chart shows 2013 end-use energy shares of buildings, industry, transportation, and other sectors.

Thailand scored 36.5 points and ranked 4th from the bottom, above South Africa, Brazil, and Saudi Arabia.

Thailand earned the top score for energy efficiency of fossil fuel thermal plants, including distribution losses, and ranked fifth on the size of its ESCOs market relative to GDP. Thailand also earned points for having a national water savings strategy and for outlining an energy efficiency plan (EEP) in the INDC plan submitted to the UNFCCC in 2015. The EEP targets a 25% reduction in end-use energy intensity between 2010 and 2030. Thailand earned average scores for the presence of building energy codes in nonresidential buildings.

In the industrial sector Thailand is one of the few countries with mandates for energy managers, energy audits, and EnMS. In the transportation sector Thailand earned full points for average on-road fuel economy of light-duty vehicles. Information was not available on government and utility spending on energy efficiency or on energy efficiency R&D investment.

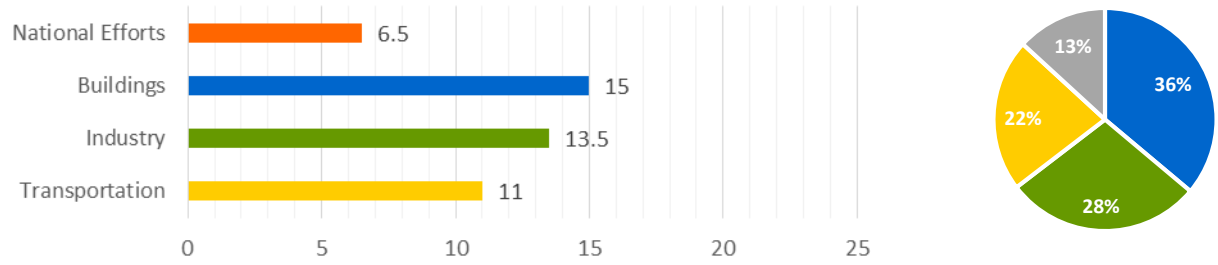
Areas for Improvement

Thailand ranked at the bottom of the list in the buildings section and below average in the other sections. Thailand has just two appliance groups covered by performance standards and no appliances covered by mandatory labeling. There is great potential for improvement in these two categories alone, as the top-performing countries have over 50 MEPS and 15 labeling standards for appliances. Thailand can also adopt mandatory building energy codes for residential buildings, as none currently exist. Furthermore the country can tighten energy performance of existing buildings and retrofits. Although some voluntary policies exist Thailand does not have any national standards for building labeling or disclosure of energy consumption.

Between 2000 and 2013 Thailand's energy intensity increased by 6.5%, more than that of any other country on the list. Thailand has no incentives to encourage private investment in energy efficiency. Other countries have various economic instruments in place such as tax incentives, loans, and grants.

In the industrial sector Thailand can improve its standing by undertaking government-led voluntary efficiency programs for various industries. Thailand could also adopt performance standards for motors and consider the benefits of CHP installation to further improve the efficiency of the power system. In the transport sector Thailand should focus on setting fuel economy standards for both light-duty passenger vehicles and heavy-duty freight trucks. Overall Thailand needs to improve its data collection and analysis of energy efficiency indicators.

TURKEY, #15



The bars show ACEEE scores for energy efficiency. The pie chart shows 2013 end-use energy shares of buildings, industry, transportation, and other sectors.

Coming in 15th, Turkey scored 46.5 points and ranked above Australia and Russia but below Poland and Taiwan.

Of the 4 categories Turkey ranked the highest in the buildings sector at 10th place. The country received the average score or above on most buildings metrics, scoring 15 of the possible 25 points. Turkey has mandatory labeling standards for 22 appliance groups and ranked 2nd on this metric, better than all the EU countries on the list. Turkey also has mandatory building labeling policies for all buildings. The country has building energy codes in place for both new construction and existing buildings.

Turkey has attractive incentives for energy efficiency in industry. It adopted the 2007 Energy Efficiency Law to support energy efficiency projects and voluntary agreements in Turkish industries. If industries commit to reducing their energy intensity by an average of 10% over a 3-year period under a voluntary agreement, the Elektrik İşleri Etüt İdaresi Genel Müdürlüğü administration will subsidize 20% of their energy costs during the first year. Turkey also performed well in energy intensity of agriculture.

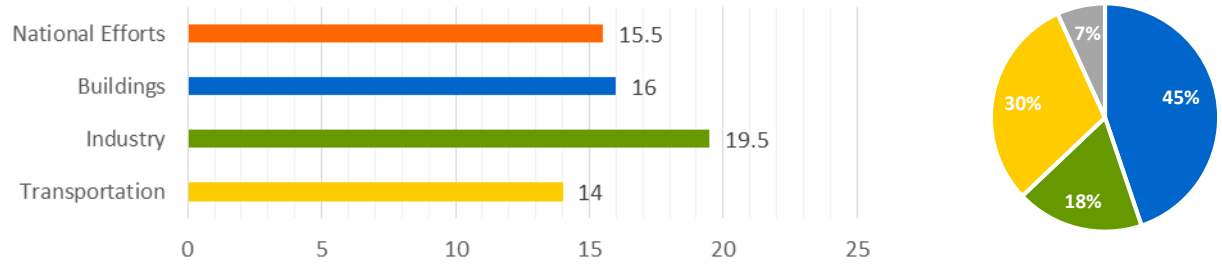
In the transportation sector Turkey's rate of public transit use is high, and its per capita use of passenger cars for personal transportation is low. No information was available on government and utility spending on energy efficiency programs.

Areas for Improvement

Turkey ranked near the bottom on national efforts toward energy efficiency. The country's energy intensity decreased by only 9% between 2000 and 2013. There are no government incentives for private investment in energy efficiency, a deficiency that also inhibits its ESCOs market. Turkey's small ESCOs market is concentrated mostly in Istanbul and exists in few other cities. In the buildings sector the country could tighten up its overall policy approach to energy efficiency by mandating energy codes for all new and existing buildings and ensuring compliance with codes.

Turkey can benefit from mandating energy audits for large energy users in the industrial sector and considering expansion of its CHP systems. To improve efficiency in its transportation sector Turkey should adopt fuel economy standards for both light-duty passenger vehicles and heavy-duty freight trucks. The country could increase its investment in rail transport to capture more energy savings.

UNITED KINGDOM, #5



The bars show ACEEE scores for energy efficiency. The pie chart shows 2013 end-use energy shares of buildings, industry, transportation, and other sectors.

This year the United Kingdom fell behind Germany, Japan, Italy, and France, with a score of 65 points. The United Kingdom has had a challenging year for energy and climate policies, as the government has rolled back a slew of energy efficiency policies. These rollbacks include

- A 33% cut to the country's Energy Efficiency Obligations target in 2014
- A 20% cut to future Energy Efficiency Obligations spending in 2015
- Cancellation of the Green Deal in 2015

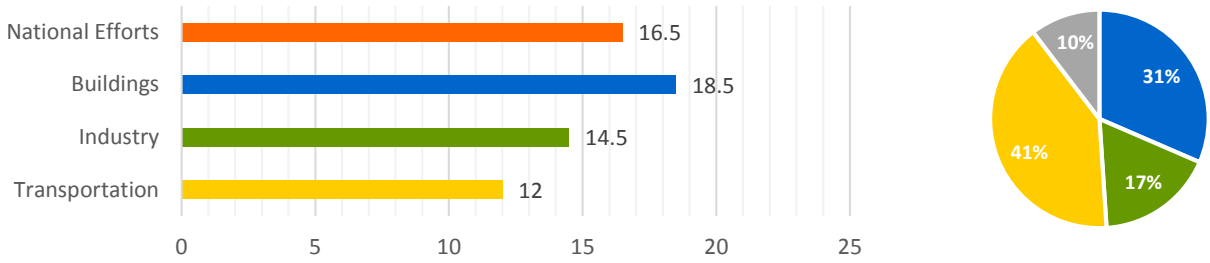
Relative to some other countries evaluated in this report, the United Kingdom still has some good policies and programs in place; however these are much weaker than they have been in the past and will be affected by the outcome of the country's vote to leave the European Union.

The United Kingdom has also made commitments to energy reduction through its national policies as a result of EU membership. The UK energy efficiency target under the EU Energy Efficiency Directive (2012/27/EU) amounts to an 18% reduction (or 28.5 Mtoe) from the United Kingdom's 2007 business-as-usual project projection for 2020, but this relies heavily on the ability to count energy savings from existing building regulations, which may not be admissible under the directive.

Areas for Improvement

The collapse of building retrofit policy since 2012 and the subsequent lack of ambition require major policy change. While the United Kingdom, following the EU directive, has strong policies to improve fuel economy and advance vehicle technologies, much more can be done to improve the overall efficiency of the freight and passenger transport systems. The United Kingdom's freight system is very energy intensive, and a very low proportion of daily travel is carried out on public transportation. Driving is still the primary mode of transport as evidenced by the relatively high VMT from passenger vehicles.

UNITED STATES, #8



The bars show ACEEE scores for energy efficiency. The pie chart shows 2013 end-use energy shares of buildings, industry, transportation, and other sectors.

The United States tied with South Korea for the 8th-place spot this year, moving up significantly from its ranking of 13th in 2014.

In the national efforts section the country stood in 5th place with a score of 16.5 points. Although this was due mainly to some changes in our methodology, the United States nevertheless scored well in a few areas in this section. The United States is one of the countries that collect energy data and make it easily accessible to both citizens and international audiences. These efforts are housed in the EIA, which publishes energy data periodically on its website and provides a number of other tools and services. Through the North American Cooperation on Energy Information (NACEI) the United States also recently collaborated with Canada and Mexico to standardize and share energy information for the region. The United States also has numerous tax incentives and loan programs to encourage energy efficiency and is focused on investing in R&D for energy-efficient technologies.

The United States also excelled in the buildings section, claiming the second spot. Of the 23 nations evaluated in this report the United States has the most mandatory appliance and equipment standards, covering more than 60 product categories. Most US states have adopted stringent building energy codes for new residential and commercial buildings and provide tools, training, and resources to support the adoption and maintenance of building codes. The United States also has state energy-use policies for retrofitting buildings, covering two-thirds of the country's population.

Areas for Improvement

Despite its leadership on a number of policies, the United States falls behind Japan, China, and most of the EU countries on our list. The United States still has no binding energy savings goals, unlike Germany, France, Japan, and other countries that have national energy conservation plans in place. The United States could take advantage of existing efficiency opportunities by mandating building energy-use disclosure policies and categorical labels for appliances.

Similarly the country could mandate energy audits and energy managers in industries. The United States scored lowest in the transportation sector, where it received only 12 points out of a possible 25. The annual VMT per capita in personal vehicles is the highest in the United States out of all the countries on our list, indicating that driving is the primary mode of transport in the country. Additionally, the average on-road fuel economy of existing light-duty vehicles is poor thanks to fuel economy standards that were stagnant until 2010. While the United States has implemented stringent fuel economy standards since then, it could achieve additional energy savings in the transportation sector by promoting public transportation and investing more in rail systems.

Appendix C. US Performance and Recommendations for Increasing US Energy Efficiency

In *The 2014 International Energy Efficiency Scorecard* the United States ranked 13th out of 16 countries evaluated, near the bottom of the pack. The United States did much better in 2016, ranking 8th out of 23 countries with an improved score of 61.5 points over the 2014 score of 42 points. This was due in part to a significant improvement in scores in both the national efforts and the buildings sections.

In the national efforts section the United States ranked fifth. Despite being one of the world's largest energy consumers the United States has no binding energy reduction plan in place, although it received points for the GHG reduction plan submitted to the UNFCCC in 2015. Nevertheless the United States has comprehensive tax credit and loan programs to encourage energy efficiency and is focused on investing in R&D for energy-efficient technologies.

In the buildings sector the United States is a leader on many fronts, claiming the second-place spot. Of the 23 nations evaluated in this report the United States has the most mandatory appliance and equipment standards, covering more than 60 product categories. The DOE has set a goal of reducing carbon pollution in the country by 3 billion tonnes cumulatively by 2030, specifically through new standards, creating the needed impetus to enact strong standards. Additionally, the United States' ENERGY STAR® labels demonstrate best practices for developing voluntary appliance and equipment standards around the world.

The United States earned 12th place in the industrial section of the analysis. The United States scored well on policies encouraging investment in CHP, which is a new metric in this edition. The United States also has one of the highest levels of investment in industrial R&D, second only to Japan.

The United States scored lowest in the transportation sector, where it received only 12 points out of a possible 25. The country excels in addressing fuel consumption in vehicles through comprehensive fuel economy standards, but the transportation system remains inefficient as a whole. The annual VMT per capita in personal vehicles is higher in the United States than in any of the other 22 countries.

Despite its numerous existing policies and the improved score on the 2016 edition of the *Scorecard*, the United States still falls behind most of the European Union as well as China and Japan. There are a number of key measures that the United States should consider adopting to fully take advantage of untapped energy efficiency potential. The following section outlines those key measures by sector.

NATIONAL EFFORTS

Establish national goals

As mentioned above the United States is one of very few large energy-consuming economies that do not have national energy reduction targets in place. A national goal would help align energy efficiency goals across sectors and create a cohesive approach to energy savings and GHG emissions reduction. Such targets can also encourage energy

efficiency actions at the state and local levels. Many of the 23 countries evaluated in this report have energy savings targets. France adopted an energy transition bill in 2015, which calls for a 20% reduction in final energy consumption by 2020 and a 50% reduction by 2050. Similarly Germany has a plan to cut GHG emissions by 40% by 2020 and up to 95%by 2050. National targets can be difficult to enforce and may not achieve the prescribed energy reductions without help from a comprehensive implementation plan. A multisector road map or action plan that incorporates checkpoints and performance metrics to gauge progress will truly allow for a comprehensive approach to energy efficiency across the country.

Enact water efficiency policies

Water and energy are inherently linked, and savings can come both from using less water (water efficiency) and from using less energy in water and wastewater systems. A number of jurisdictions in the United States have come to acknowledge this link, particularly those that have been severely water constrained in recent years (e.g., California). At the national level the federal government can take a number of actions to ensure that this link is maintained. These include investing in R&D programs that target the enhancement of water efficiency and passing policies to encourage collaboration and innovation between the utility and water sectors. One of the largest sources of water consumption is in condensers for electricity generation. Likewise water is a very electricity-intensive resource, as electricity is required for many functions such as pumping water for agriculture and sourcing, treating, transporting, and disposing of wastewater.

BUILDINGS

Improve building retrofit policies

The United States is a leader on national buildings policies, but older, more inefficient residential and commercial buildings provide a huge energy savings opportunity in the United States. US building codes are implemented at the state and local levels. While most jurisdictions have codes that apply to existing structures in addition to new commercial and residential buildings, these codes could be made significantly more ambitious by either requiring building renovations to be conducted by a certain date regardless of whether other construction is being undertaken, or requiring the improvement of overall building energy performance when any building extension, addition, or conversion is done. France for instance requires that all residential and commercial buildings that fall into the two lowest building rating bands be renovated by 2025 (BPIE 2015). Similarly the renovation policy in the United Kingdom prohibits a private landlord from renting out spaces unless he or she improves the building's energy rating to at least E level (BPIE 2015). Policies such as those described above would encourage a faster rate of renovation and improve the overall efficiency of these older buildings.

Improve transparency of energy use

One of the biggest barriers to energy efficiency investments is improper information. As a complement to comprehensive building codes and retrofit policies, state and local governments can make building owners and renters aware of their energy footprint by implementing requirements that make the energy use and costs of both residential and commercial buildings transparent at the point of sale or lease. This could be achieved

through a mandatory labeling or rating system that compares buildings on their relative energy use.

INDUSTRY

Expand scope of voluntary agreements

US performance in the industrial section of the *2016 Scorecard* was marginally above average. The United States has solid policies in place to encourage CHP deployment as well as comprehensive equipment standards, but it would realize greater energy savings in the industrial sector by focusing on expanding the scope of voluntary partnerships between the government and large manufacturers. The federal government could set targets for reductions in industrial energy use that would encourage the adoption of a globally recognized manufacturing standard such as ISO 50001. It could then require manufacturers that enter into these partnerships to submit comprehensive energy reduction plans for their facilities. Increased participation by large manufacturers in the DOE's Superior Energy Performance (SEP) program would also strengthen voluntary partnerships to significantly improve energy performance and create leaders in industrial efficiency.

Increase industry workforce development

Increasing federal investment in workforce development and training programs such as DOE's Industrial Assessment Center (IAC) program leads to energy savings. IACs are located at universities across the country and train young engineers to conduct energy audits for small- and medium-sized manufacturers to help improve efficiency, reduce waste, and increase productivity. Students are a major focus of the IAC program, which has increased the number of students who pursue energy efficiency careers and has taught them skills that are highly valued by the private sector (SRI 2015). IACs have conducted more than 16,000 free audits since 1981 that have resulted in approximately 54 million MMBtus in gross energy savings and more than 6 million tonnes of avoided CO_2 emissions (SRI 2015).

TRANSPORTATION

Maintain or strengthen light-duty fuel economy

The United States has already taken significant strides to reduce fuel consumption in the transportation sector by implementing fuel economy and GHG emission standards for light-duty vehicles out to 2025. In order to fully realize the savings potential of these standards the United States will need to ensure that the upcoming midterm review finds that these standards deliver fuel savings and GHG emissions reductions at least as great as those originally projected for the program. If the provisional standards are maintained during the review, fuel savings between model years 2022 and 2025 will average out to 4% per year. This is also the time to set out a more ambitious target for 2030.

Strengthen heavy-duty vehicle fuel economy

Heavy-duty vehicles are similarly subject to fuel efficiency and GHG standards in the United States. Phase 1 of the standards was adopted in 2011 and impacts medium- and heavy-duty trucks from model year 2014 onward. Phase 2 is expected to be adopted in the summer of 2016. The proposed phase 2 standards together with phase 1 would reduce the average fuel consumption of new trucks to 35% lower than 2010 levels by model year 2027.

Strengthening the final phase 2 standards to achieve a 40% fuel consumption reduction would help to draw advanced efficiency technologies into the market.