WORLD ECONOMIC FORUM

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Industry Agenda

Global Energy Architecture Performance Index Report 2017

Prepared in collaboration with Accenture

World Economic Forum
91-93 route de la Capite
CH-1223 Cologny/Geneva
Switzerland
Tel.: +41 (0)22 869 1212
Fax: +41 (0)22 786 2744
Email: contact@weforum.org
www.weforum.org

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Chief Expert Advisers

Morgan Bazilian, Lead Energy Specialist, World Bank
Davide Puglielli, Senior Manager, Strategy and Mergers and Acquisitions, Enel
David Victor, Professor of International Relations and Director, Laboratory on International Law, University of California, San Diego; Chair, Global Agenda Council on Governance for Sustainability
Eirik Wærness, Senior Vice-President and Chief Economist, Statoil

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Contributors

Project Adviser: Accenture Strategy - Energy

Muqsit Ashraf, Managing Director
James Collins, Managing Director
Michael Moore, Senior Manager
Tessa Lennartz-Walker, Manager
Richard Standring, Consultant, (Lead Author)
Additional acknowledgements: Christian von Celsing, Chhavi Maggu, Jenna Trescott

World Economic Forum

Roberto Bocca, Head of Energy and Basic Industries, Member of the Executive Committee
Espen Mehlum, Head of Knowledge Management and Integration, Energy Industries (Project Lead)
Thierry Geiger, Head of Analytics and Quantitative Research, Global Competitiveness and Risks
Additional acknowledgements: Roderick Weller

Foreword

Roberto Bocca
Head of Energy and Basic Industries and Member of the Executive Committee, World Economic Forum

Muqsit Ashraf
Managing Director, Accenture Strategy - Energy

This report marks the fifth annual edition of the global Energy Architecture Performance Index (EAPI), which examines the progress of the global energy transition – that of moving towards more sustainable, affordable and secure energy systems – by benchmarking the energy systems of 127 countries.

During the World Economic Forum Annual Meeting 2012 in Davos-Klosters, Switzerland, executives of the world's largest energy companies, policy-makers and thought leaders from across the energy value chain were asked: *To what extent do you expect global energy systems to change over the next ten years?* An overwhelming 90% expressed the belief that significant change would occur across energy architectures around the world, and nearly one-third predicted a radical shift in the way energy is sourced, transformed and consumed.

Five years on and at the midway point, the world has indeed witnessed unprecedented structural changes in the global energy system, as evidenced across the three sides of the "energy triangle":

Economic growth and development: World energy consumption has continued to grow since 2012, albeit at a slower rate than seen in the previous decade. Much of this growth has been driven by developing countries, whose development is founded on energy. The economics of producing this energy have experienced significant change. The average price of oil in 2016 was 60% lower than five years ago.[1] The emergence of unconventional oil, rising energy efficiency and slowing growth in emerging markets contributed to a sustained supply glut and a downtrend in prices starting at the end of 2014. In response, planned global upstream capital spending was cut by over 30%,[2] with some predicting a potential hydrocarbon shortage as a result. By 2015, the basket of the world's top 20 oil and gas companies had lost a third of their market value (1)(2). Contrastingly, 10 of the world's biggest utility companies have seen their combined market capitalization increase by over 26%.[3]

Environmental sustainability: Global power markets are transforming in favour of sustainable infrastructure. The share of solar in world power generation has almost doubled every two years since 2000, and every four years for wind. With each doubling, the cost of solar falls 24% and that of wind, 19% (3). These trends suggest a permanent shift in the energy mix of the future, marked by a decline in coal consumption, the rising importance of natural gas and renewables, and improved energy productivity in major economies, such as China and the United States. Growing electrification of the world's secondary energy supply, and the digitization of the grid, are indicative of a shift in energy systems and their sustainability. Nowhere is electrification more prominent than in the growing market for electric vehicles; pre-orders for Tesla's new model in 2015 broke the record for the single biggest one-week product launch in history (4).

In November 2016, the Paris Agreement on climate change came into force – a landmark moment for the international community committed to collectively accelerating the transition to a clean-energy economy. The adoption of the United Nations 2030 Agenda for Sustainable Development and the Sustainable Development Goals also signalled renewed emphasis on the need for affordable, clean energy.

Energy access and security: Many countries have set forth ambitious plans for their new energy architectures, aiming to take advantage of technological developments and diversify the composition of their supplies to meet rising energy needs and increase security. Countries have increasingly looked to drive security through exploiting indigenous renewable and fossil fuel energy sources. The United States' shale boom has placed the country in a position where it is expected to become a net exporter of gas this decade, having lifted its 40-year ban on crude oil exports in 2016. Liquefied natural gas (LNG) has gained share in the world energy market, coinciding with regional shifts in trade and historical importers becoming exporters, and vice versa. The emergence of a more flexible global market is further signalled by almost a third of LNG now trading on the spot market, as compared to almost exclusively on fixed-term contracts in the past. The oversupplied market has placed more power into buyers' hands, with significant impact on countries' supply mixes, diversification strategies and trading relationships. For instance, alongside rising domestic energy demand and threatened export revenues, Saudi Arabia, the world's largest oil producer, has set diversification goals in its 2030 Vision.

Below the surface of the momentous shifts of the past five years, the energy system has started to turn, much akin to a colossal tanker pointing in a new direction but still very far from its destination. Although many countries have made important leaps forward, average performance of countries on the index has been generally sluggish, increasing by less than two basis points over the last five years. The EAPI reveals that countries continue to face residual challenges as they look to make progress on their energy systems, complicated by unforeseeable factors and market instability. Overall global economic recovery has been slow, the Fukushima Daiichi power plant disaster rattled public opinion and stalled prospects for nuclear energy, and low oil prices have slashed investment. Moreover, energy supply spending is at its lowest level since 2010 (5).

The composition of the world's energy consumption changed very little from 2010 to 2014. A 1.4% increase in renewables (including hydropower and biofuels) over this period contrasts with slight decreases in liquid fuels and natural gas, while coal consumption increased by 0.2% (6). The rise of renewables in the electricity sector has been more pronounced, as they overtook coal as the world's largest source of power capacity, although not generation, in 2016 (7). Access to electricity remains a major challenge; over 17% of the world's population still has no access, and many more suffer from poor quality of supply (8). While global investment in renewable energy has risen, investment in developed countries has declined since peaking in 2011 (9). Much work remains to meet the ambitious targets ratified in the Paris Agreement following the United Nations 21st annual Conference of the Parties (COP21). In March 2016, and for the first time since records were kept, global levels of carbon dioxide were sustained above 400 parts per million for one month (10).

Looking ahead to the next five years, and with many conflicting scenarios around the demand for energy, the transition to a more sustainable, affordable, secure and inclusive energy system has taken on a pronounced urgency and immediacy. The digitization of the economy and the energy system will be a boon for energy-sector actors to leverage in order to drive the transition, although it will also lead to new complexities requiring management, not least from a security perspective. Managing the transition to a new energy architecture is not easy. The imperatives of the energy triangle may reinforce or act in tension with each other, forcing difficult trade-offs to be made. As nations contemplate how to respond to changing energy dynamics and implement global commitments, this year's report highlights the lessons learned from top performers on the EAPI and presents a guide for steering energy systems through transition.

Ambition of the Global Energy Architecture Performance Index

The EAPI, developed by the World Economic Forum in collaboration with Accenture, looks at trends and the real performance of countries' energy systems. Since its launch five years ago, the EAPI has contributed to the global benchmarking of energy systems, highlighting topical energy issues and providing guidance on making energy transitions more effective. This year's report includes the findings from benchmarking 127 countries on 18 indicators covering contribution to economic growth and development, environmental sustainability, and energy access and security. Like any index, the EAPI cannot fully reflect the complexity of energy systems or of managing energy transitions. It can, however, serve to benchmark the performance of national energy systems, providing a basis for comparison across nations. The EAPI offers the latest available global energy data, aiding policy formation by providing a reliable indicator of strengths and target areas for improvement.

Executive summary

The results of the global Energy Architecture Performance Index (EAPI) 2017 highlight key trends in the energy transition moving towards more sustainable, affordable and secure energy systems around the world, as well as the challenges countries continue to face, individually and as cohorts. Looking back at five years of data from the EAPI, this report also distils insights from countries that have shown significant improvements in performance or remained consistently high performers.

EAPI 2017: Key insights

- **Top performers come in all shapes and sizes:** While many of this year's top performers tend to be smaller countries, both in size of gross domestic product and population, and typically have advanced economies, a significant number of countries do not fit this mould. These exceptions demonstrate that few constraints are limiting high performance. In fact, top performers come in all shapes and sizes. Their many variations underscore the potential for any country to make improvements in providing secure, affordable and sustainable energy to its population, regardless of its context.
- **European countries dominate the leader board:** As in previous years, countries from Europe continue to hold many of the top 20 ranks on the EAPI, with the exceptions of **Colombia (8th), New Zealand (9th), Uruguay (10th)** and **Costa Rica (14th)**. This strong performance is underpinned by advantages gained through a long history of coordination between European nations, which is a model for regional cooperation. These countries score particularly high on using market forces (reflected in low levels of price distortion) and on the diversity of their energy mix. However, many of them have significant room for improvement, especially in continuing to ensure security of supply given the low level of resource endowment across the continent.
- **The world's biggest energy consumers are being outperformed:** Major energy consumers continue to struggle to take leading positions on the EAPI. While showing strengths in certain areas, and early signs of strong trajectories in others, **China (95th), India (87th), Japan (45th),** the **Russian Federation (48th)** and the **United States (52nd)** have either slipped in the rankings since the EAPI 2009 benchmark or experienced only marginal gains. Their energy consumption dwarfs that of the highest-performing top 20. Big consumers need to intensify their efforts and overcome the inherent challenges of their large, complex energy systems; doing so will allow them to make a disproportionately positive impact on global energy architecture. With the world's energy markets underpinned by the global economy's performance, the global energy sector will continue to be challenged for as long as these countries – some of the largest economies in the world – have difficulty exceeding average performance.
- **Top-ranked countries and the rest of the table exhibit a growing divide in performance:** Since last year, the top 20 highest-performing countries have achieved twice the average increase in EAPI score compared to that of all other countries. This difference in improving performance reflects a further strengthening of energy sectors in countries already performing well, and an opportunity for other countries to understand these journeys more closely – ultimately so that they can interpret these in the context of their own transitions.

The global energy system is often perceived as slow to change, which is reflected by the modest improvement of less than two basis points in average score versus the EAPI 2009 benchmark. However, a number of countries have made significant improvements in this time frame and climbed the ranks, challenging the view of collective inertia. Examining the journeys of Uruguay, Mexico and Jamaica, which have made strides in their energy sector performance since 2009, and those of Sweden and France, both of whom have been consistently high performers, revealed three principles of energy-sector governance to effectively steer energy systems through transition:

- **Frame the long-term direction for the energy sector, and commit to it:** Change takes a long time to enact in energy systems. Today's energy landscape looks very different compared to a decade ago, and will likely be significantly different in another 10 years' time.

Governments that steer their energy systems through these changes with long-term visions provide important continuity across these extended time frames. A long-term frame provides a vision for the energy sector's many stakeholders to embrace and sets the boundary conditions for the transition. Long-term visions must be flexible to adapt to changing energy-sector realities, new emerging technologies and unforeseeable hindrances.

- **Enable the energy transition with adaptable, co-designed policies:** The policies most effective at advancing a country's energy transition are those enabling solutions that best suit a country's context. This means creating the necessary opportunities for innovation to flourish, and providing flexibility for the most appropriate technologies to emerge organically. While governments formulate the policies, other stakeholders are ultimately relied on to implement the changes and achieve the goals set. For effective implementation, good policy design involves the implementing institutions and end-users to rigorously test policies and assess their potential to drive the desired impact. Through this process and before implementation, an important sense of joint ownership is defined between formulators and executors, instilling among all parties a clear understanding of the policy's intent.
- **Steward investment to the most impactful areas:** Significant investment is required to make progress on the energy transition and to meet growing demand for energy. The International Energy Agency estimates that $48 trillion in investment is needed globally to meet energy needs to 2035 (11). The stability of committing to a long-term vision is a must for establishing investor confidence. Once promoted, private-sector investment requires stewardship to guarantee it is focused on the right areas. Innovative approaches are required to ensure this is done to maintain an attractive investment environment. In addition, choosing the right public-private partnership model is key to promoting investment while protecting national interests.

Now more than ever, decision-makers must understand the core objectives of energy architecture – generating economic growth and development in an environmentally sustainable way while providing access to energy and energy security for all – and how changing dynamics affect them. Steering energy systems to a future state that is more affordable, sustainable and secure is a long-term endeavour with significant challenges for any country. However, that endeavour is worthwhile because the benefits of success are great. Energy is a prerequisite for all sectors of an economy, and reliable energy promotes economic and social development by boosting productivity and facilitating income generation. So it follows that energy availability should affect job availability, national productivity and the overall quality of life.

Methodology

Background

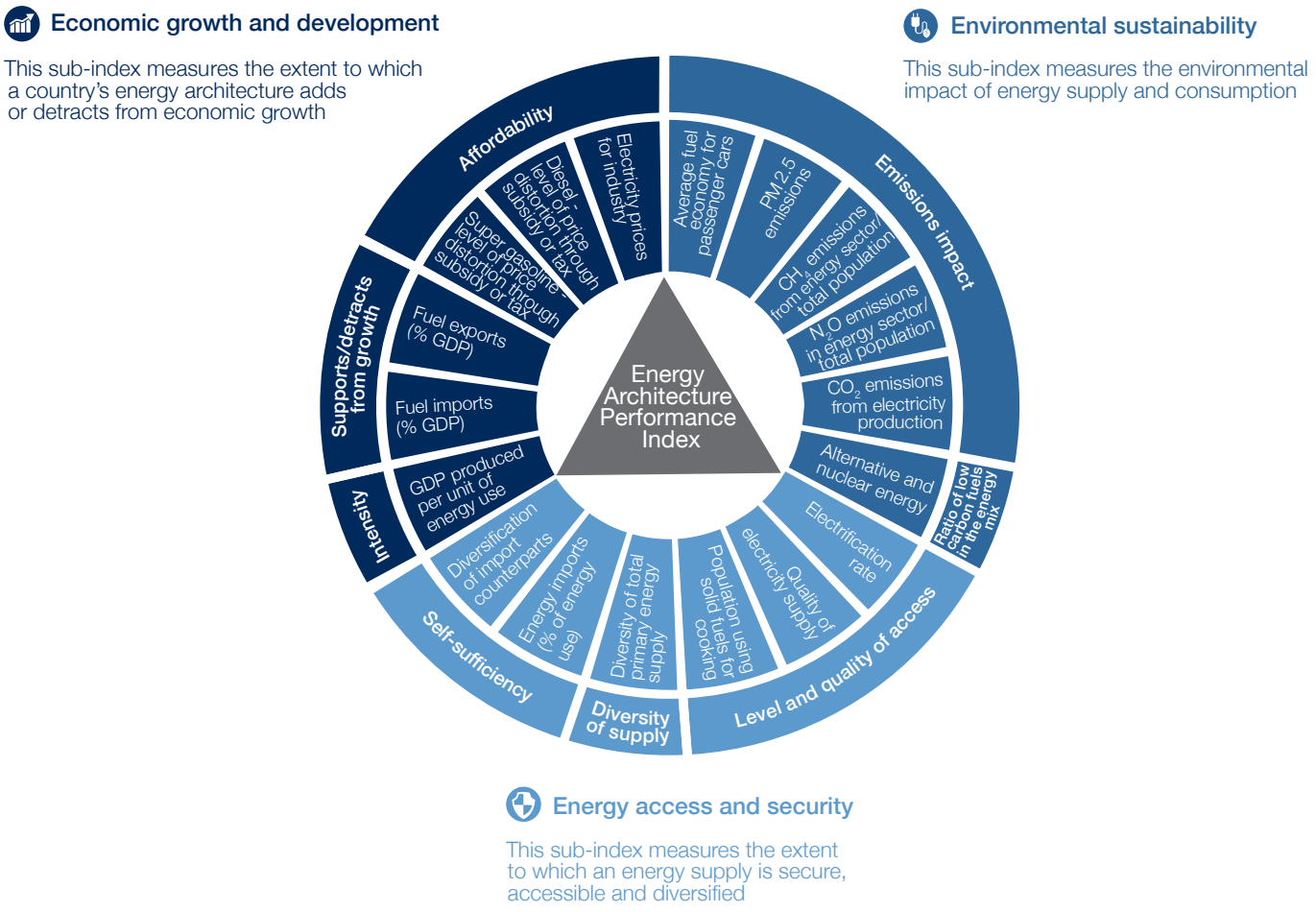
Since 2013, the EAPI has provided a tool for decision-makers to help better understand energy systems and to assess the current energy architecture performance of individual nations.

Methodology

The EAPI is a composite index that focuses on tracking specific indicators to measure the energy system performance of 127 countries. At its core are 18 indicators defined across the three sides of the "energy triangle", which are: economic growth and development, environmental sustainability, and energy access and security (Figure 1).

Scores (on a scale of 0 to 1) and associated rankings are calculated for each of these indicators. These are then aggregated based on defined weights to calculate a score and ranking for each sub-index and for the EAPI overall. A methodological addendum on the EAPI can be found in the appendices on page 24, and the full methodology is available online at http://wef.ch/eapimethodology.

Figure 1: The energy architecture performance index and its indicators



Source: World Economic Forum and Accenture analysis

EAPI 2017 results

Figure 2: The energy architecture performance index 2017 ranking and results

Economic growth and development
Environmental sustainability
Energy access and security

	Country	2017 score[1]				2009-17 trend[2]
1	Switzerland	**0.80**	0.74	0.77	0.88	▲ (+1)
2	Norway	**0.79**	0.67	0.75	0.95	▼ (-1)
3	Sweden	**0.78**	0.63	0.80	0.90	▲ (+1)
4	Denmark	**0.77**	0.69	0.71	0.91	▲ (+1)
5	France	**0.77**	0.62	0.81	0.88	▼ (-2)
6	Austria	**0.76**	0.67	0.74	0.88	▲ (+2)
7	Spain	**0.75**	0.65	0.73	0.87	▲ (+4)
8	Colombia	**0.75**	0.73	0.68	0.83	▲ (+2)
9	New Zealand	**0.75**	0.59	0.75	0.90	▲ (+3)
10	Uruguay	**0.74**	0.69	0.71	0.82	▲ (+15)
11	Portugal	**0.74**	0.63	0.73	0.85	▲ (+2)
12	Finland	**0.73**	0.55	0.79	0.87	▼ (-6)
13	Slovenia	**0.73**	0.58	0.73	0.88	▲ (+6)
14	Costa Rica	**0.73**	0.68	0.76	0.74	▼ (-5)
15	United Kingdom	**0.72**	0.62	0.66	0.89	(=)
16	Ireland	**0.72**	0.69	0.65	0.81	▲ (+6)
17	Latvia	**0.71**	0.62	0.73	0.80	(=)
18	Croatia	**0.71**	0.63	0.68	0.84	▲ (+12)
19	Germany	**0.71**	0.62	0.64	0.88	▼ (-5)
20	Slovak Republic	**0.71**	0.56	0.74	0.84	▲ (+12)
21	Hungary	**0.71**	0.62	0.72	0.79	▲ (+8)
22	Paraguay	**0.70**	0.68	0.81	0.62	▲ (+2)
23	Luxembourg	**0.70**	0.73	0.62	0.76	▲ (+14)
24	Romania	**0.70**	0.66	0.65	0.79	▲ (+15)
25	Albania	**0.70**	0.63	0.78	0.70	▲ (+10)
26	Iceland	**0.70**	0.38	0.90	0.82	▼ (-10)
27	Peru	**0.70**	0.75	0.64	0.70	▼ (-9)
28	Argentina	**0.70**	0.78	0.59	0.73	▲ (+21)
29	Italy	**0.70**	0.58	0.67	0.84	▼ (-6)
30	Brazil	**0.70**	0.58	0.71	0.80	▼ (-23)
31	Czech Republic	**0.69**	0.58	0.62	0.88	▲ (+5)
32	Canada	**0.69**	0.58	0.61	0.88	▼ (-4)
33	Netherlands	**0.69**	0.54	0.65	0.88	▼ (-13)
34	Belgium	**0.69**	0.52	0.71	0.83	▼ (-7)
35	Lithuania	**0.68**	0.57	0.70	0.78	▼ (-9)
36	Azerbaijan	**0.67**	0.65	0.57	0.79	▲ (+9)
37	Poland	**0.67**	0.66	0.56	0.80	▲ (+4)
38	Greece	**0.67**	0.61	0.59	0.81	▼ (-4)
39	Singapore	**0.67**	0.65	0.55	0.81	▼ (-1)
40	Chile	**0.67**	0.60	0.58	0.82	▲ (+16)
41	Turkey	**0.66**	0.59	0.62	0.78	▲ (+2)
42	Bulgaria	**0.66**	0.57	0.65	0.76	▲ (+10)
43	Korea, Rep.	**0.66**	0.59	0.54	0.85	▲ (+5)
44	Mexico	**0.66**	0.61	0.62	0.75	▲ (+15)
45	Japan	**0.66**	0.57	0.56	0.84	▼ (-24)
46	Tajikistan	**0.65**	0.45	0.80	0.71	▲ (+20)
47	Panama	**0.65**	0.66	0.64	0.65	▼ (-7)
48	Russian Federation	**0.65**	0.55	0.60	0.80	▼ (-15)
49	El Salvador	**0.65**	0.53	0.71	0.70	▲ (+1)
50	Indonesia	**0.65**	0.58	0.64	0.72	▲ (+11)
51	Israel	**0.65**	0.60	0.49	0.84	▼ (-5)
52	United States	**0.65**	0.54	0.50	0.89	▲ (+2)
53	Australia	**0.64**	0.65	0.40	0.88	▲ (+7)
54	Congo, Rep.	**0.64**	0.61	0.76	0.55	▼ (-23)
55	Georgia	**0.64**	0.46	0.74	0.72	▼ (-13)
56	Estonia	**0.64**	0.57	0.60	0.75	▼ (-5)
57	Morocco	**0.64**	0.59	0.56	0.76	▲ (+14)
58	Armenia	**0.63**	0.49	0.72	0.70	▼ (-1)
59	Sri Lanka	**0.63**	0.70	0.61	0.59	▼ (-4)
60	Philippines	**0.63**	0.57	0.65	0.67	▲ (+3)
61	Cuba	**0.63**	0.74	0.51	0.64	▼ (-17)
62	Kazakhstan	**0.62**	0.54	0.55	0.77	▼ (-4)
63	Dominican Republic	**0.62**	0.64	0.56	0.65	▲ (+21)
64	Thailand	**0.61**	0.53	0.54	0.78	▲ (+9)

	Country	2017 score[1]				2009-17 trend[2]
65	Tunisia	**0.61**	0.43	0.62	0.79	▼ (-18)
66	Namibia	**0.61**	0.59	0.74	0.49	▲ (+13)
67	Cyprus	**0.60**	0.59	0.55	0.65	▲ (+3)
68	Ecuador	**0.60**	0.49	0.61	0.69	▼ (-4)
69	Guatemala	**0.59**	0.46	0.73	0.58	▼ (-7)
70	Serbia	**0.59**	0.50	0.54	0.73	n/a
71	Malta	**0.58**	0.60	0.54	0.61	▼ (-3)
72	Nicaragua	**0.58**	0.46	0.70	0.59	▲ (+23)
73	Ukraine	**0.58**	0.30	0.65	0.79	▲ (+4)
74	Ghana	**0.58**	0.60	0.70	0.43	▲ (+6)
75	Macedonia, FYR	**0.58**	0.50	0.51	0.72	n/a
76	South Africa	**0.58**	0.58	0.53	0.62	▲ (+10)
77	Vietnam	**0.57**	0.44	0.59	0.70	▲ (+21)
78	Bolivia	**0.57**	0.38	0.59	0.74	▼ (-3)
79	Republic of Moldova	**0.57**	0.41	0.61	0.69	▲ (+9)
80	Cameroon	**0.57**	0.53	0.78	0.40	▼ (-8)
81	Algeria	**0.57**	0.39	0.56	0.75	▼ (-28)
82	Honduras	**0.56**	0.43	0.72	0.53	▲ (+18)
83	Kenya	**0.55**	0.45	0.83	0.38	▲ (+4)
84	Bosnia and Herzegovina	**0.55**	0.48	0.52	0.66	▲ (+5)
85	Uzbekistan	**0.55**	0.43	0.57	0.66	n/a
86	Malaysia	**0.55**	0.34	0.50	0.82	▼ (-3)
87	India	**0.55**	0.54	0.49	0.62	▲ (+4)
88	Zambia	**0.55**	0.45	0.89	0.30	▼ (-7)
89	Belarus	**0.55**	0.36	0.62	0.66	▼ (-15)
90	Egypt, Arab Rep.	**0.55**	0.41	0.53	0.71	▼ (-12)
91	Botswana	**0.55**	0.59	0.56	0.49	▲ (+2)
92	Jamaica	**0.54**	0.43	0.56	0.64	▲ (+24)
93	Sudan	**0.54**	0.46	0.77	0.39	n/a
94	Kyrgyz Republic	**0.54**	0.23	0.75	0.63	▼ (-25)
95	China	**0.53**	0.46	0.42	0.72	▼ (-1)
96	Brunei Darussalam	**0.53**	0.45	0.41	0.74	▼ (-11)
97	Venezuela	**0.53**	0.30	0.61	0.68	▼ (-32)
98	Mozambique	**0.53**	0.41	0.90	0.28	▼ (-8)
99	Cambodia	**0.53**	0.58	0.66	0.35	▲ (+16)
100	Zimbabwe	**0.53**	0.40	0.78	0.41	▼ (-8)
101	Pakistan	**0.52**	0.48	0.49	0.59	▲ (+11)
102	Cote d'Ivoire	**0.52**	0.46	0.73	0.38	▼ (-26)
103	Senegal	**0.52**	0.49	0.58	0.49	(=)
104	Bangladesh	**0.51**	0.63	0.43	0.46	▲ (+9)
105	Libya	**0.50**	0.32	0.48	0.71	▼ (-38)
106	Iraq	**0.50**	0.48	0.29	0.73	n/a
107	United Arab Emirates	**0.50**	0.40	0.28	0.81	▼ (-11)
108	Jordan	**0.49**	0.43	0.40	0.66	▲ (+9)
109	Trinidad and Tobago	**0.49**	0.38	0.42	0.69	▼ (-4)
110	Nigeria	**0.49**	0.41	0.72	0.35	▼ (-28)
111	Togo	**0.49**	0.40	0.78	0.29	▲ (+9)
112	Mongolia	**0.49**	0.38	0.50	0.58	▼ (-3)
113	Nepal	**0.49**	0.46	0.67	0.33	▼ (-3)
114	Ethiopia	**0.49**	0.32	0.88	0.26	(=)
115	Kuwait	**0.48**	0.42	0.18	0.84	▼ (-8)
116	Qatar	**0.48**	0.41	0.25	0.77	▼ (-19)
117	Turkmenistan	**0.47**	0.29	0.34	0.78	▼ (-6)
118	Haiti	**0.47**	0.48	0.69	0.24	▼ (-10)
119	Tanzania	**0.47**	0.36	0.80	0.24	▼ (-17)
120	Iran, Islamic Rep.	**0.46**	0.27	0.36	0.75	▼ (-14)
121	Saudi Arabia	**0.46**	0.36	0.21	0.81	▼ (-17)
122	Oman	**0.45**	0.30	0.27	0.78	▼ (-23)
123	Eritrea	**0.44**	0.30	0.64	0.39	▼ (-22)
124	Benin	**0.44**	0.39	0.61	0.32	▼ (-5)
125	Lebanon	**0.44**	0.42	0.37	0.53	▼ (-7)
126	Yemen, Rep.	**0.42**	0.53	0.31	0.40	▼ (-4)
127	Bahrain	**0.37**	0.15	0.24	0.73	▼ (-6)

Advanced economies
Emerging and developing Europe
Latin America and the Caribbean
Commonwealth of Independent States
Emerging and developing Asia
Sub-Saharan Africa
Middle East, North Africa and Pakistan

Notes: – For the EAPI 2017 methodology, see the methodological addendum at the end of this report.
– Country scores are rounded to two decimal places, but exact figures are used to determine rankings. Therefore, countries with the same EAPI score may have different rankings.

[1] EAPI 2017 score on a scale of 0 to 1

[2] Change in ranking versus the 2009 benchmark

Key findings

The following sections explore the key findings from this year's EAPI, including insights from top performers, the most significant changes in performance, and opportunities for improvement across specific sides of the energy triangle. This information was analysed making use of the latest data from the EAPI.

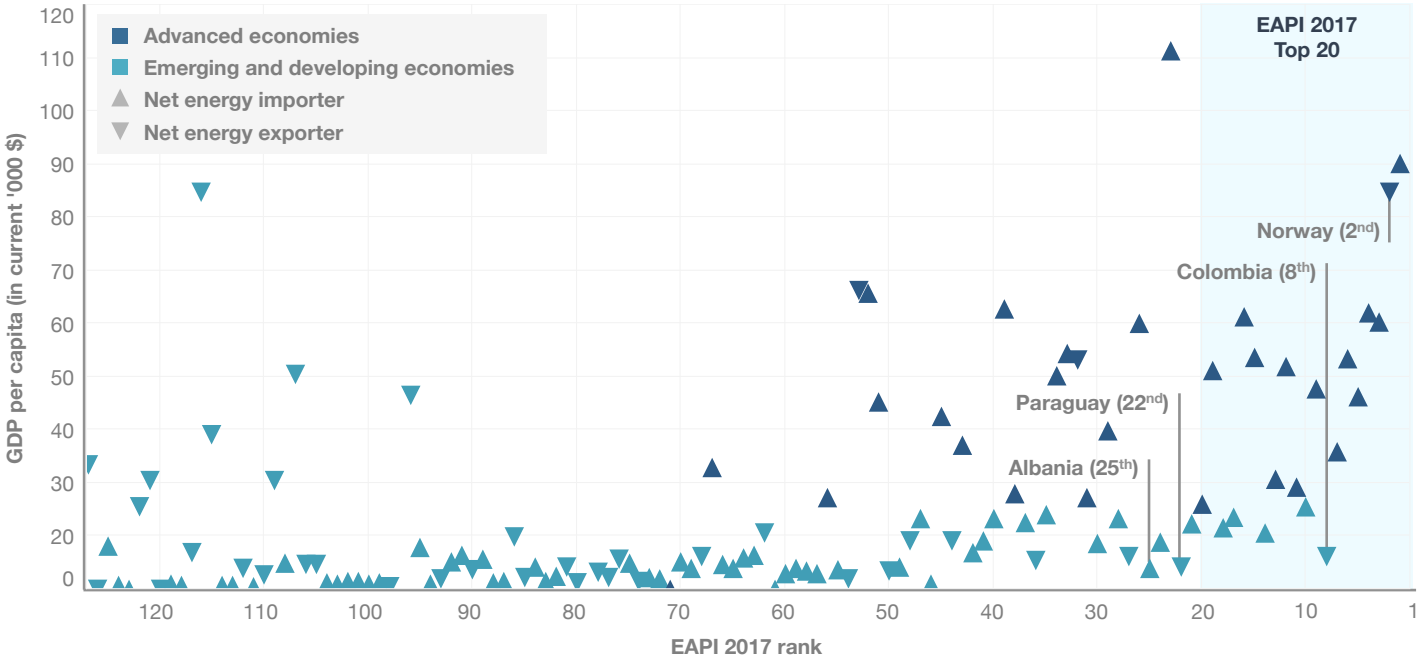
Top performers come in all shapes and sizes

This year's list of top performers remains fairly stable against the 2016 cohort. **Ireland (16th), Germany (19th)** and the **Slovak Republic (20th)** are the only new entrants in the top 20. Top performers share a number of characteristics. They tend to be smaller countries – for example, **Switzerland (1st), Uruguay (10th), Portugal (11th)** and **Slovenia (13th)** – which makes it comparatively easier to enact changes in their energy systems than in those of larger countries. Most of the highest performers are also advanced economies, defined principally as having a high level of gross domestic product (GDP) per capita, diversified exports, and being well integrated into the global financial system (12).

However, a significant number of countries do not fit this mould and demonstrate that few boundary constraints limit high performance. In fact, high performers come in all shapes and sizes. While small economies are common, **France (5th)**, the **United Kingdom (15th)** and **Germany (19th)** are examples of large economies, defined in GDP, that are also top 20 performers on the EAPI. And, although the top 20 commonly have a high GDP per capita, an advanced economy by no means guarantees a high-performing energy sector, nor is it a prerequisite (Figure 3). **Paraguay (22nd)** and **Albania (25th)** are strong examples of this, with GDPs per capita in the bottom 40% for the cohort, yet are found in the top 20% on the EAPI. Countries with large supplies of natural resources are at an advantage in being able to boost their economies and provide their populations with secure, low-cost energy, if managed well. However, the majority of the top 20 are net importers of energy, reflecting their lack of natural resource endowment, with the exceptions of **Norway (2nd)** and **Colombia (8th)**, as net exporters, and **Denmark (4th),** which is close to parity on this metric.[4] These net importers of the top 20 show that weaknesses on individual indicators can be overcome through a balanced focus on others.

The many variations in the contexts of the top performers underscores the potential of any country to make improvements in providing secure, affordable and sustainable energy to its population, regardless of its economy's size, its level of advancement, geographical region or exporter status.

Figure 3: Top performers come in all shapes and sizes
EAPI 2017 rank mapped against GDP per capita and net energy importer/exporter status



Source: World Economic Forum and Accenture analysis

European countries dominate the leader board

Switzerland (1st) tops the rankings for the third consecutive year, benefiting from a diverse supply mix, low-energy intensity and low carbon dioxide (CO_2) emissions from electricity production. It has continued to improve its scores since last year in economic growth and development (5th to 3rd) and environmental sustainability (18th to 16th), staying constant for energy access and security (7th). Switzerland has achieved improvements or maintained its position across all EAPI indicators, with the exception of the diversification of its import counterparts, where it moved from 52nd to 63rd, highlighting a need to consider further diversifying these sources. However, clouds are on the horizon, with negotiations on bilateral energy agreements with the European Union (EU) recently stalling after the referendum on immigration, and with the United Kingdom's vote to leave the EU, which is likely to impact these discussions.

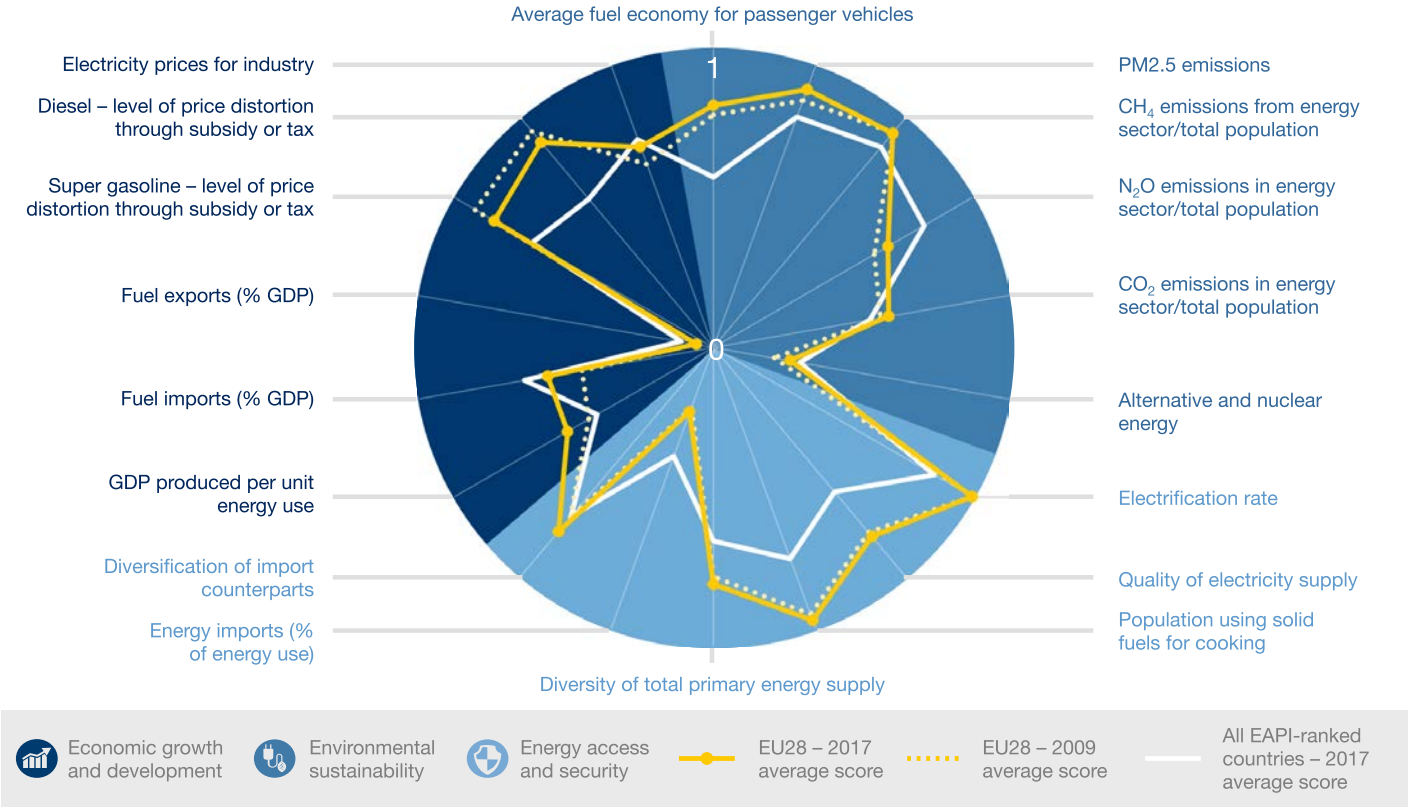
Switzerland is followed closely by **Norway (2nd), Sweden (3rd), Denmark (4th)** and **France (5th)**, cementing their position as the top five countries on the EAPI from last year (with France and Denmark switching ranks). Nordic economies have successfully balanced performance across each side of the energy triangle. Norway ranks 1st on energy access and security, reflecting how it has successfully translated a high supply of natural resources into benefits across its entire energy system. Sweden ranks in the top 10 globally on environmental sustainability, with investment in renewables paying off. From being heavily reliant on oil in the 1970s to achieving one of the highest shares of renewables across the EU, it has reached 50% of consumption from renewable energy before the 2020 deadline. Denmark is 8th on economic growth and development, achieving low levels of energy intensity and competitive energy prices.

The 28 Member States of the EU (EU28) dominate the top of the EAPI, making up 14 of the 20 highest-performing countries and all sitting in the top half of the table, with the exception of **Cyprus (67th)** and **Malta (71st)**. While not part of the EU, Norway and Switzerland also benefit from many of the factors driving this group's success. As a cluster, the EU28 outperform the average on 13 of 18 indicators (Figure 4). The group has maintained or increased its score on all indicators compared to the 2009 EAPI benchmark, with the exception of the two indicators measuring price distortion for gasoline and diesel fuel. This drop in score is indicative of the general trend in the EU of increasing taxes on fuels. The more modest decrease in the score for diesel price distortion reflects an overall lower rate of tax on this fuel compared to gasoline. This difference has contributed to an increasing "dieselization" of the EU's vehicle fleet, encouraged by governments nudging their populations towards a higher average fuel economy for passenger vehicles (the increase for this indicator, averaged across the EU28, was 0.03 in the 2009-2017 period).

The EU28's performance is underpinned by advantages gained through a long history of regional coordination between Member States, which began almost three decades ago when the European Commission started to focus on cross-border trade and increasing competition for lower energy prices. The first initiatives to liberalize the energy market in the 1990s targeted electricity and gas, with the focus in the new millennium shifting first to renewable energy targets and then to energy security issues (13). In 2007, An Energy Policy for Europe set objectives covering all three sides of the energy triangle. The results to date of these ongoing efforts include strong regional infrastructure links, increased cross-border trade in gas and electricity, and healthy levels of competition across the entire energy value chain. The impact of these efforts is reflected in the EU28's EAPI scores, which are particularly high on the use of market forces (low levels of price distortion for gasoline [0.85] and diesel [0.90]) and diversity of the total primary energy supply (0.79).

As a cohort in general, the EU28 is challenged by a lack of natural resources, resulting in a high dependence on imports (scoring 0.23 for energy imports as a percentage of GDP) and limited contribution of fuel exports to its economies (0.06). In addition to a wide diversity of import counterparts (0.81), the advantages of regional integration contribute to mitigating these weaknesses and maintaining high-performing energy sectors. Recognizing these benefits, the EU's Energy Union is set to further strengthen the internal energy market as well as address other areas for improvement, including security of supply and sustainability of the regional energy system, as reflected in targets embedded in the Energy Strategy for 2020, 2030 and 2050 (14). However, much work remains to be done to meet these targets, not least in sustainability. Alternative and nuclear energy, as a percentage of the EU28's total primary energy supply, is notably low, and lags behind the overall average. With the exceptions of Sweden, France and Finland, none of the Member States exceed 50% on this metric. While the cohort has made marginal gains in this area since 2009 (from 0.21 to 0.26), a long path remains to achieving the targeted levels of decarbonization in the energy mix.

Figure 4: Average indicator scores for European Union (EU28) and all EAPI countries*



* EU28 scores for 2017 and 2009; all 127 EAPI-ranked countries scores for 2017
Source: World Economic Forum and Accenture analysis

The world's biggest energy consumers are being outperformed

Major energy consumers continue to struggle to take leading positions on the EAPI. While showing strengths in certain areas, and early signs of strong trajectories in others, **China (95th), India (87th), Japan (45th)**, the **Russian Federation (48th)** and the **United States (52nd)** have either slipped in the rankings since 2009 or experienced only marginal gains. The energy consumption of these nations dwarfs that of the highest-performing top 20 (Figure 5). Big consumers need to intensify their efforts and overcome the inherent challenges of their large, complex energy systems; doing so will allow them to make a disproportionately positive impact on global energy architecture. With the world's energy markets underpinned by the global economy's performance, the global energy sector will continue to be challenged for as long as these countries, which are some of the largest economies in the world, find it difficult to exceed average performance.

China (95th) is showing signs of tackling the significant challenge to enable rapid growth of its energy sector while also balancing the three sides of the energy triangle. The world's largest energy consumer drops one place in this year's rankings. The country's strongest score is for diversification of import counterparts, where it achieves first place globally. While China has taken significant steps to respond to growing air pollution, sustainability remains the greatest challenge (112th on this side of the energy triangle). China lags behind other global superpowers, with high levels of energy intensity (107th) and high CO_2 emissions from electricity production (102nd) impacting its comparative performance. To improve energy-sector competitiveness, China is taking targeted action across its energy system. The 13th Five-Year Plan includes targets and measures to address key issues, such as air pollution and climate change, and ranges from setting mandatory targets for cutting emissions and improving efficiency to launching a nation-wide carbon market. China also pledged to reduce energy intensity by 60-65% by 2030 as part of the Paris Agreement.

India (87th) is gradually improving its performance on the EAPI (90th last year). Similar to China, the country boasts a strong score on the indicator for diversification of import counterparts (5th), but its energy system continues to face some significant challenges, particularly in environmental sustainability (109th). India has some of the lowest scores in the EAPI for CO_2 emissions from electricity production and PM2.5 levels (117th and 123rd, respectively). While sources of pollution are diverse and intermittent (e.g. agricultural crop burning, refuse combustion, fireworks), the energy sector is a large, consistent contributor to this issue of major concern. Many solutions have been attempted with varying degrees of impact, but the country sorely needs a comprehensive plan of action to implement an effective and sustainable answer.

India also faces an uphill battle to increase energy access and security (95th). A large percentage of the population still lacks access to electricity (101st) and uses solid fuels for

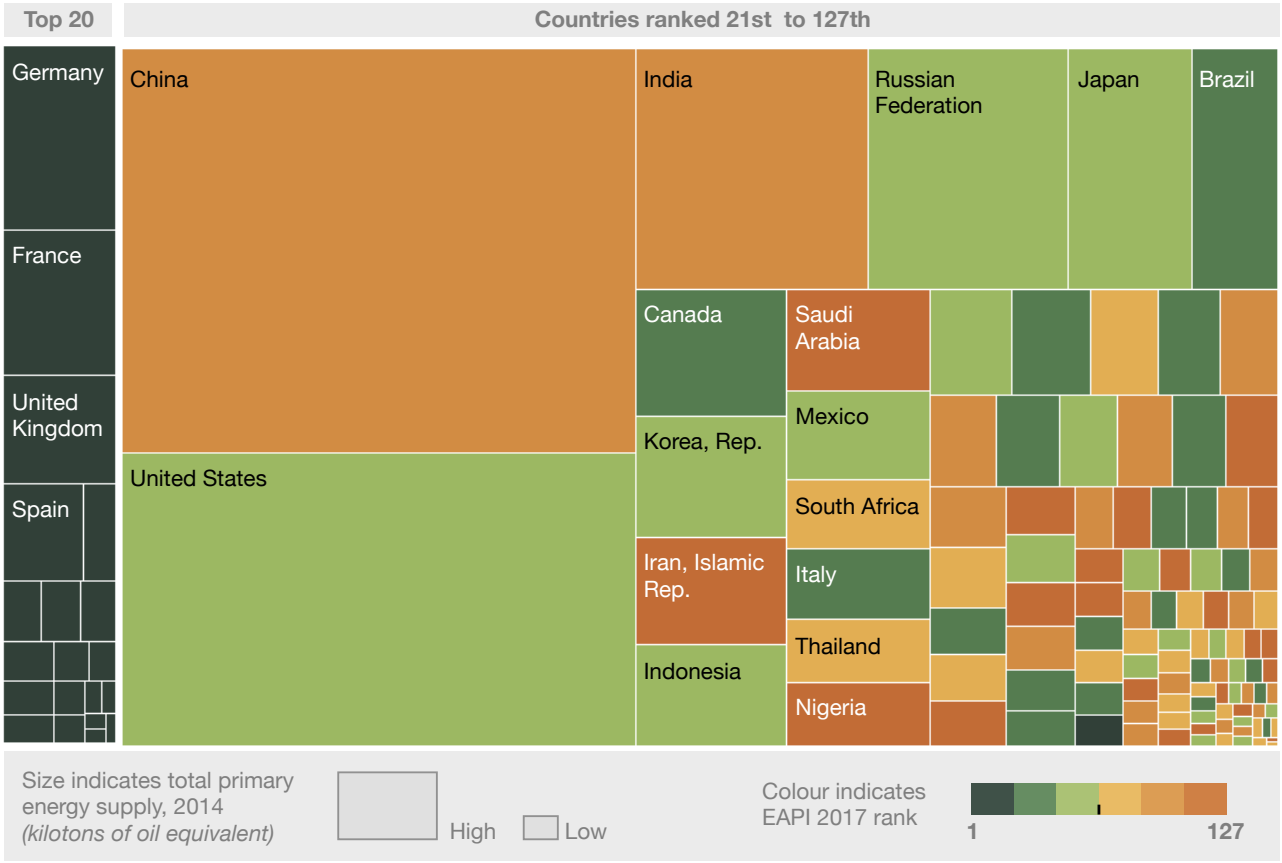
cooking (108th). The government of Prime Minister Modi is taking action on this, having committed to increase solar power capacity to 100 gigawatts by 2022, which would make India a leader in renewable capacity.

This year, **Japan (45th)** has managed to turn around its declining performance on the EAPI for the first time since placing 21st in the 2009 benchmark and reaching a low of 51st last year. This indicates the country is beginning to overcome the long-lasting impact of the 2011 Fukushima Daiichi nuclear disaster on its energy sector. Japan is diversifying its energy import counterparts (15th), from which it imports fossils fuels that now dominate its total primary energy supply. Expensive imported fossil fuels filled a 30% gap left in the electricity supply following the disaster (15). The effects of this are still clearly present on all sides of the energy triangle, particularly in indicators measuring electricity prices for industry (55th), use of alternative and nuclear energy (102nd), CO_2 emissions from electricity production (88th) and net energy imports as a percentage of energy use (121st). Japan faces many challenges, and restarting its nuclear power reactors is of primary importance to overcoming many of them, judged as "critical" to the success of the country's energy policy, according to the International Energy Agency (IEA) (15). In the meantime, the country is taking advantage of new opportunities to drive improvements in the energy sector, notably the deregulation of its retail and generation electricity markets in 2016. By creating one of the largest deregulated electricity markets in the world, this move may help to significantly modernise Japan's energy sector and lower hiked prices.

The **Russian Federation (48th)** has improved its ranking marginally since last year. Its energy sector remains heavily reliant on oil and gas, with a weak performance on the proportion of renewable energy in its total primary energy supply (92nd). Its highest score was on energy access and security (37th), due to a high level of self-sufficiency. The country's performance on the EAPI points to high energy intensity (110th) and high levels of fossil fuel subsidies (105th and 102nd for gasoline and diesel, respectively), as well as areas for improvement within environmental sustainability (75th overall). While the sector has long acted as an engine for growth in the country, contributing over 25% of GDP (16), the challenges Russia faces will only become more acute given the current headwinds, most notably the lower price of oil.

When compared to last year, the **United States (52nd)** has dropped four places. It achieves its highest score on energy access and security (5th), and has an increasingly diverse total primary energy supply (19th). The surge in shale gas and growing investment in renewables, especially solar, underscores this performance. It lags behind its peers in the Organisation for Economic Co-operation and Development (OECD) on environmental sustainability (105th), with particularly low scores on indicators relating to emissions. The country still has to tackle a high energy intensity (86th). Overall, the context is shifting, with the low price of oil at the root of declining investment in oil and gas and of lower production levels, and increased regulations on emissions likely to impact the future shape of its energy architecture.

Figure 5: World's largest consumers dwarf the energy consumption of highest-performing countries



Source: World Economic Forum and Accenture analysis

The performance divide between top-ranking countries and the rest of the table is growing

Compared to last year, the average increase in the EAPI score of the group of top-20 highest-performing countries is double that of all other countries. This growing difference in the magnitude of performance improvement between the two groups reflects a further strengthening of the energy sectors of countries that already perform well.

The rate of improvement displayed by these highest-performing countries is driven primarily by improvements across economic growth and development, with the group's average improvement on sub-index almost three times that for all other countries. Improving the role of the energy system in a country's economy is often the most difficult task, as reflected by this sub-index being the consistently lowest-performing one, year to year. It is also the most volatile, fluctuating in response to swings in the global economy. This highlights the challenges policy-makers face to ensure their transitioning energy systems are competitive and resilient to unforeseeable events. The above-average improvement of the top 20 in this area was in part due to much stronger improvement in the indicator measuring electricity prices for industry, demonstrating the group's ability to pass on lower commodity prices through market pricing mechanisms. The group has mostly benefited from the fall in the price of oil, seeing less of a decrease in the score measuring fuel exports as a percentage of GDP. This also highlights the lack of dependency on the production and trade of fossil fuels in many of the group's economies.

Where the rest of the table has averaged a decrease in environmental sustainability, the highest performers have maintained a steadily strong performance. This is primarily tied to the majority of these countries making incremental improvements in the ratio of low-carbon fuels in their energy mix and improving average fuel economy for passenger vehicles. The average increase in energy access and security for the top 20 is in line with that of the rest of the cohort. Energy security is a key concern, as many of these countries' energy sectors depend on energy imports.

Steering energy systems through transition

The global energy system is often perceived as slow to change, as reflected by the modest improvement in the 2017 average EAPI score compared to the 2009 benchmark (0.78 vs 0.77). However, a number of countries are challenging this view of collective inertia, having significantly improved their rank since 2009 (Figure 6); those include **Jamaica (116th to 92nd), Nicaragua (95th to 72nd), Tajikistan (66th to 46th), Mexico (59th to 44th), Luxembourg (37th to 23rd)** and **Uruguay (25th to 10th)**. Achieving such improvements is no small feat, no matter what the starting point. As policy-makers pursue their own improvements, they often look for lessons learned from analogous countries. Regrettably, no solution can be seen as a one-size-fits-all remedy, and the differences between countries mean that each needs to find its particular path.

However, some commonalities surface when looking at the journeys of these most-improved countries. This section draws on examples from three of them to examine some of the factors that have supported improved performance. The countries have been selected from the bottom, middle and top third of the rankings to represent a diverse range of baseline starting points.

The three countries from the list of most improved are:

- **Uruguay** – A small nation that made big step changes in the performance of an already strong energy system
- **Mexico** – A large country that made significant improvements (from a starting point almost in line with the average) while undergoing a dramatic series of cross-sector reforms
- **Jamaica** – A regional leader in transitioning to a sustainable energy system, whose national energy policy is now praised as a model for lawmakers across the region

Additional examples among the consistently high performers exhibit similar commonalities:

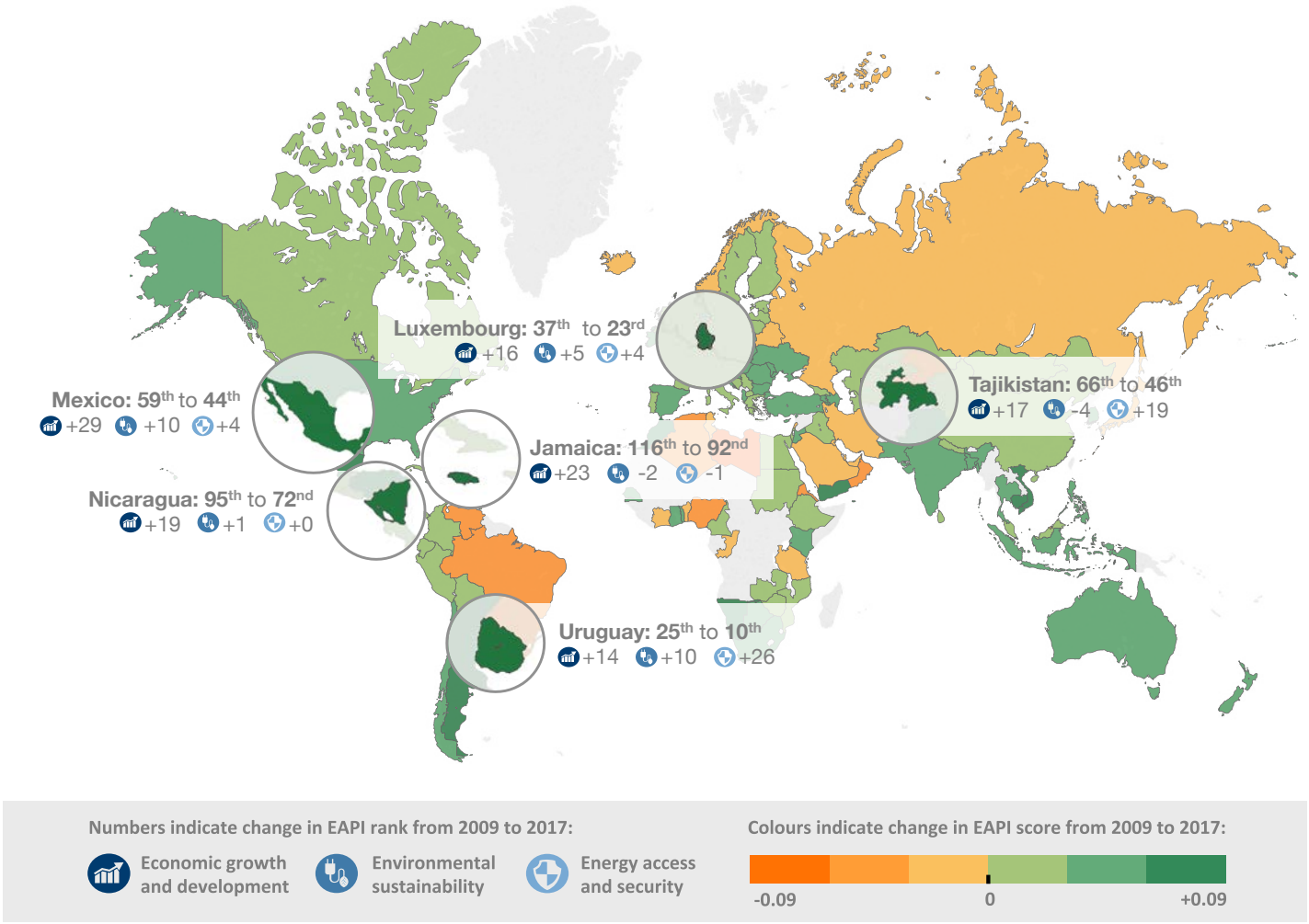
- **France** – With an advanced economy, the country is speeding up its energy transition following implementation of the Paris Agreement to diversify its nuclear-dominated energy mix, reduce emissions and strengthen security of supply
- **Sweden** – Over the last few decades, the nation has moved to a position where it can easily meet most energy demands domestically, and is now pursuing a strong series of sustainable energy policy objectives

As explored earlier in this report, many factors influence the direction of an energy system. But closer examination of these countries' journeys reveals three principles that are effective for steering energy systems through transition. These are:

1. **Frame the long-term direction for the energy sector, and commit to it**
2. **Enable the energy transition with adaptable, co-designed policies**
3. **Steward investment to the most impactful areas**

These principles are mutually reinforcing, building on each other to create affordable, secure and sustainable energy systems. A clear frame and long-term direction is needed to form the basis of policy goals and provide a sense of stability required to encourage investment. Adaptable, co-designed policies establish the conditions for achieving the energy sector's vision. Stewardship of investment directs the capital required to support the energy transition to the right projects that will drive progress. Taken together, these principles have been shown to contribute to high-performing energy sectors and generate significant improvements, as explored in the next section.

Figure 6: Significant improvements in EAPI ranks among many countries (2009 to 2017)

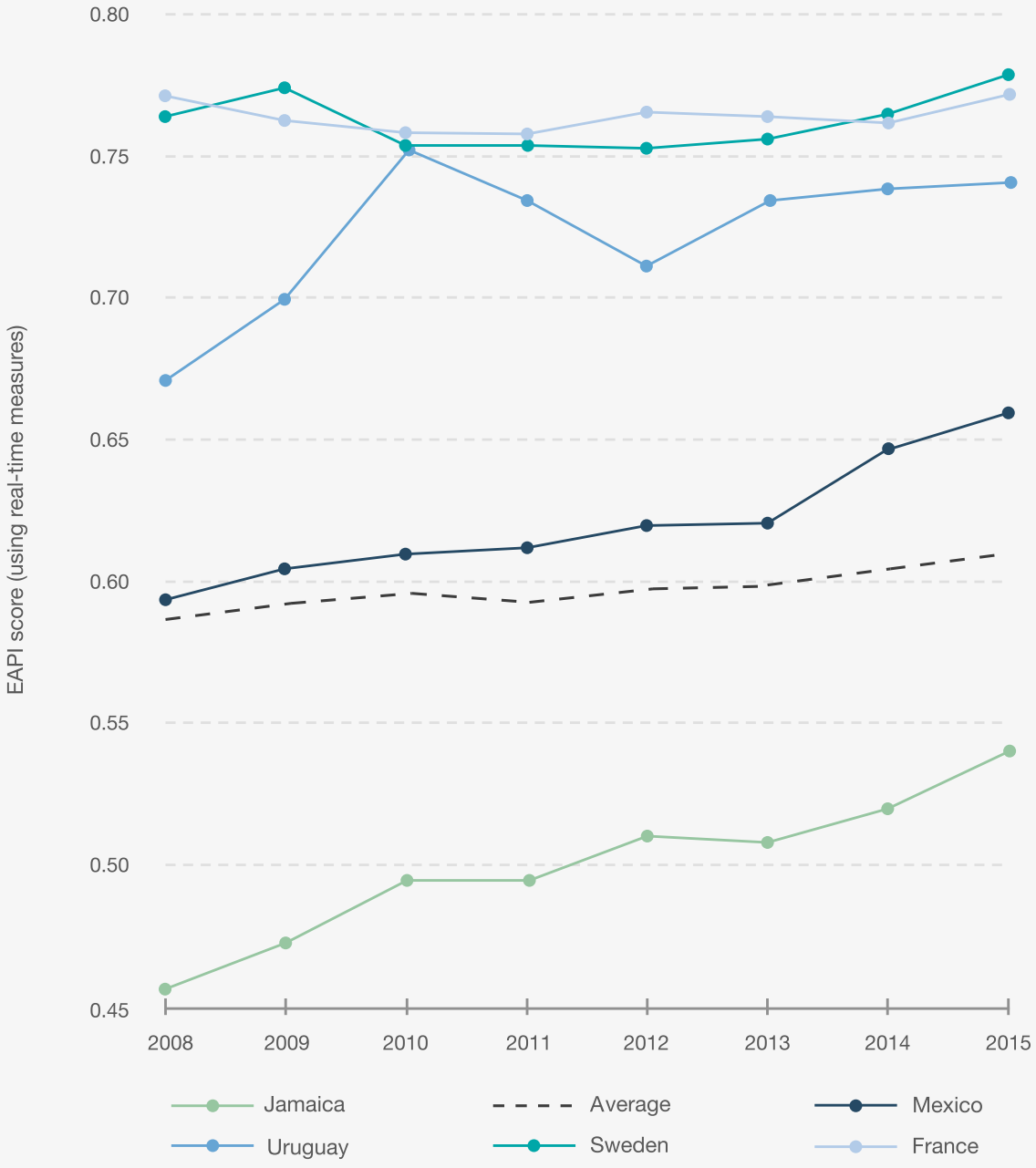


Source: World Economic Forum and Accenture analysis

Country focus

This section sets the context of the energy sectors of France, Sweden, Uruguay, Mexico and Jamaica, before drawing examples from these countries as they relate to the three principles for steering energy systems through transition. The time series analysis throughout this section uses "real-time" measures for the EAPI. In other words, the EAPI methodology has been applied retrospectively for the years 2009 to 2015, aligning the year of the data source to the year of the EAPI score as far as possible (Figure 7). For example, the real-time EAPI 2013 score is primarily based on data sources published for the year 2013. This allows clear links to be drawn between changes in energy-sector performance and causal events.

Figure 7: Movement of EAPI scores of selected countries compared to the average



Source: World Economic Forum and Accenture analysis

Uruguay's total primary energy supply comprises biowaste and hydropower sources, with a growing share of wind and solar, and a large proportion of oil despite the lack of any national hydrocarbon reserves. The country has bolstered its lead over the average EAPI score with balanced performance improvements across all three sides of the energy triangle in the period covered by the time series. In particular, greater diversification of energy sources (0.61 to 0.76) through an increase in renewable energy generation and capacity (0.34 to 0.54), and a reduction in fuel imports (0.27 to 0.83) have driven this improvement. Closer inspection of Uruguay's performance on the EAPI shows how external events can test an energy system's strength. Its performance peaked in 2010, reflecting the recovery from a 2008 drought that significantly affected hydropower, a large component of Uruguay's capacity to generate electricity. This phenomenon was repeated in 2012. In such situations, the shortfall is covered by importing electricity from Argentina and using imported oil to generate electricity, both of which have an adverse impact on several indicators. Diversifying the energy supply, which has in part driven Uruguay's improving performance, addresses this vulnerability.

Mexico is a net exporter of energy principally due to its vast hydrocarbon reserves. The country's well-diversified total primary energy supply is dominated by these sources, but includes a growing share of renewables, which have significant potential. Under President Enrique Peña Nieto's leadership, Mexico is undergoing broad reforms in education, financial regulation, taxation, anti-trust, telecommunications and, not least, energy. Major changes in the energy sector include ending a state monopoly on oil and gas exploration and production, transitioning continuously to a low-carbon economy, and gradually liberalizing fossil-fuel prices. The principle driver of Mexico's accelerated performance was the 2013 decision to phase out fuel subsidies (see Figure 7 for the impact of this move), with the underlying indicators for gasoline and diesel price distortion both ultimately reaching 0.67, from 0.46 and 0.28, respectively. Furthermore, integrating state utility companies into a single entity that is operated more like a private-sector company has significantly improved the quality of electricity supply (0.51 to 0.65).

Jamaica's total primary energy supply is highly dependent on imported fossil fuels, with well over 90% of its electricity sourced from petroleum-based power plants (17). In recent years, lower commodity prices have partially helped to improve the island's EAPI score by driving an increase in the indicator measuring fuel imports as a percentage of GDP (0.00 to 0.34). In general, Jamaica has generated small but steady improvements across all sides of the energy triangle, including reducing the distortion of fuel prices (0.46 to 0.77 for gasoline, and 0.57 to 0.71 for diesel) and increasing the quality of electricity supply (0.53 to 0.62). If other measures are not taken, the improvement in fuel imports as a percentage of GDP will last only as long as low prices. However, Jamaica is taking steps to reduce the volume of imports as well; it is continuing to decrease energy intensity (0.29 to 0.36), and is taking increasing advantage of alternative forms of energy (0.14 to 0.19) by using its impressive potential in renewable energy. If exploited, renewables could meet 100% of electricity demand (17). Jamaica's most recent energy policy goals lay out aggressive targets, namely for renewables to reach a 30% share of the energy mix and for energy intensity to be reduced by 50% by 2030.

Sweden is one of Europe's greatest success stories for clean energy production. In 1970, oil accounted for over 75% of the country's total primary energy supply. The decade's ensuing oil shocks forced a rebalancing of the energy mix, to a point where low-carbon renewable sources now account for the largest proportion of total primary energy supply, followed closely by nuclear. At the same time, Sweden increased the reliability and comprehensiveness of its energy infrastructure. Accordingly, the country's consistently high performance was driven by world-class scores on indicators from all sides of the energy triangle, including percentage of energy use from alternative and nuclear energy (0.71), CO_2 emissions from electricity production (0.96), PM2.5 levels (1.00), electrification rate (1.00), quality of electricity supply (1.00), electricity prices for industry (0.88) and percentage of population using solid fuels for cooking (1.00).

France's total primary energy supply is dominated by nuclear power, due to a long-standing policy based on energy security. In fact, nuclear power currently generates about three-quarters of the electricity supply. Because the cost of generating electricity is low, the country is the world's largest net exporter of electricity, which contributes over €3 billion annually to the economy (18). These are the foundational factors for France's continuously high performance, driving some of the highest scores on the EAPI on the environmental sustainability and the energy access and security sub-indexes (0.81 and 0.88, respectively). More recently, the country has sought to diversify its total primary energy supply away from nuclear, capping this capacity and expanding renewable energy sources to account for 32% of consumption by 2030. Many challenges remain on the path to meeting this ambitious target, including navigating potential supply shortages that result from nuclear reactors being taken offline.

Examining the journeys of **Uruguay, Mexico** and **Jamaica**, which have made strides in their energy sector performance since 2009, and those of **Sweden** and **France**, both of whom have been consistently high performers, revealed three principles that are effective for steering energy systems through transition. This section explores the principles and draws on examples from these countries.

1. Frame the long-term direction for the energy sector, and commit to it

Energy sectors are characterized by long investment cycles, as the scale and complexity of their infrastructure mean that change takes time to plan, enact and create an impact. Scale and complexity are critical, demanding a patient and incremental approach. Moreover, because energy architecture is both a local and global issue, nations need to understand the broader implications of their actions, and the international constraints they may face, when creating enabling environments.

Setting a frame for the long-term direction of the energy sector helps to stay the course, from planning changes to seeing results. Governments go through several cycles within such long time frames, with room for disruption and substantial change in the sector and the global economy. Today's energy landscape looks very different to how it did a decade ago, and will likely look significantly different in another ten years' time. Importantly, to bring greater balance to the energy triangle and enable an effective transition, policy-makers must look to the long term, providing a more stable policy environment based on in-depth understanding of the trade-offs they make. Where possible, decision-makers should aim to take actions that result in positive net benefits for all three imperatives of the triangle. A frame needs to establish a clear vision and direction, while being flexible enough to adapt to changing realities and overcome unforeseeable blocks.

A long-term frame provides a vision for the energy sector's many stakeholders to embrace. As such, a credible commitment to this vision is critical towards creating the required confidence – for stakeholders to make meaningful progress and for investors to commit capital. Credible commitment from the top levels of government means making public declarations of intent that are in line with the vision, and embedding that vision in policy and legislation where appropriate. It further means passing the mandate to act on this vision on to institutions that outlast individual government leaders. This provides a clear and unifying direction for all stakeholders and investors to work towards and be confident that priorities will not change.

Uruguay's long-term vision through to 2030[5] is comprehensive, covering all sides of the energy triangle and providing a clear direction for the sector, while at the same time being inherently flexible. The government has made its vision credible by reaching a consensus on policy among many stakeholders, including opposing political parties, and by having built and involved strong institutions that are independent from politics, such as the national energy companies, Usinas y Trasmisiones Eléctricas (UTE) covering electricity, and Administración Nacional de Combustibles, Alcohol y Portland (ANCAP) covering fuels.

Mexico's established a clear long-term energy strategy through major energy reform, with the main goal to offset a steep decline in hydrocarbon production by accessing untapped deep-water and unconventional reservoirs. The reform materialized shortly before the decline in the price of oil; however, the government's strongly underlined commitment to the strategy has been key to keeping operators interested in the country's potential. In 2014, Mexico's president demonstrated the government's commitment to the energy transformation when he signed the 21 parts of Mexico's energy reform into law. Legislation divides the mandate for regulatory oversight of the sector into five separate agencies. And beyond exploiting new hydrocarbon reserves, the country has a clear target for clean energy sources to provide 35% of total generation capacity by 2024, rising to 50% by 2050 (19).

Jamaica's commitment to its long-term 2030 vision for the energy sector is established in the highest level of government. The prime minister has set a clear mandate for every Jamaican to be part of its implementation. The vision is embedded throughout the national energy policy, which in turn is translated into strategies and specific areas of action, such as diversifying fuel sources and developing renewables. The mandate for administering these is given to a range of ministries, agencies and departments.

France's vision for its energy sector was founded strongly on energy security, in response to the first oil shock in 1974. The French government's strong commitment to this vision over the following decades served as a foundation for establishing the country's massive nuclear power capacity. More recently, the vision, set out to 2030, has shifted to include greater focus on energy efficiency, reduced emissions and a larger share of renewables in final energy consumption. In 2007, France created a single ministry with the mandate to deal with energy, the environment and land-use, as well as transport issues, in an integrated way under one banner of sustainable development. The size of this ministry, and the importance it has in the overall institutional framework, is a clear signal of France's continued commitment to its vision for energy transition (20).

2. Enable the energy transition with adaptable, co-designed policies

Energy policies are the tools governments can use to set the conditions for transforming their energy sectors. Quality policies formalize a government's vision for the energy sector, setting realistic short-, medium- and long-term goals that direct and drive progress. A compelling link exists between well-designed policies, as measured by the World Bank's Regulatory Quality Indicator[6], and the highest-performing countries on the EAPI (Figure 8), highlighting how important policies are to the sector's governance and to achieving a top-performing energy system.

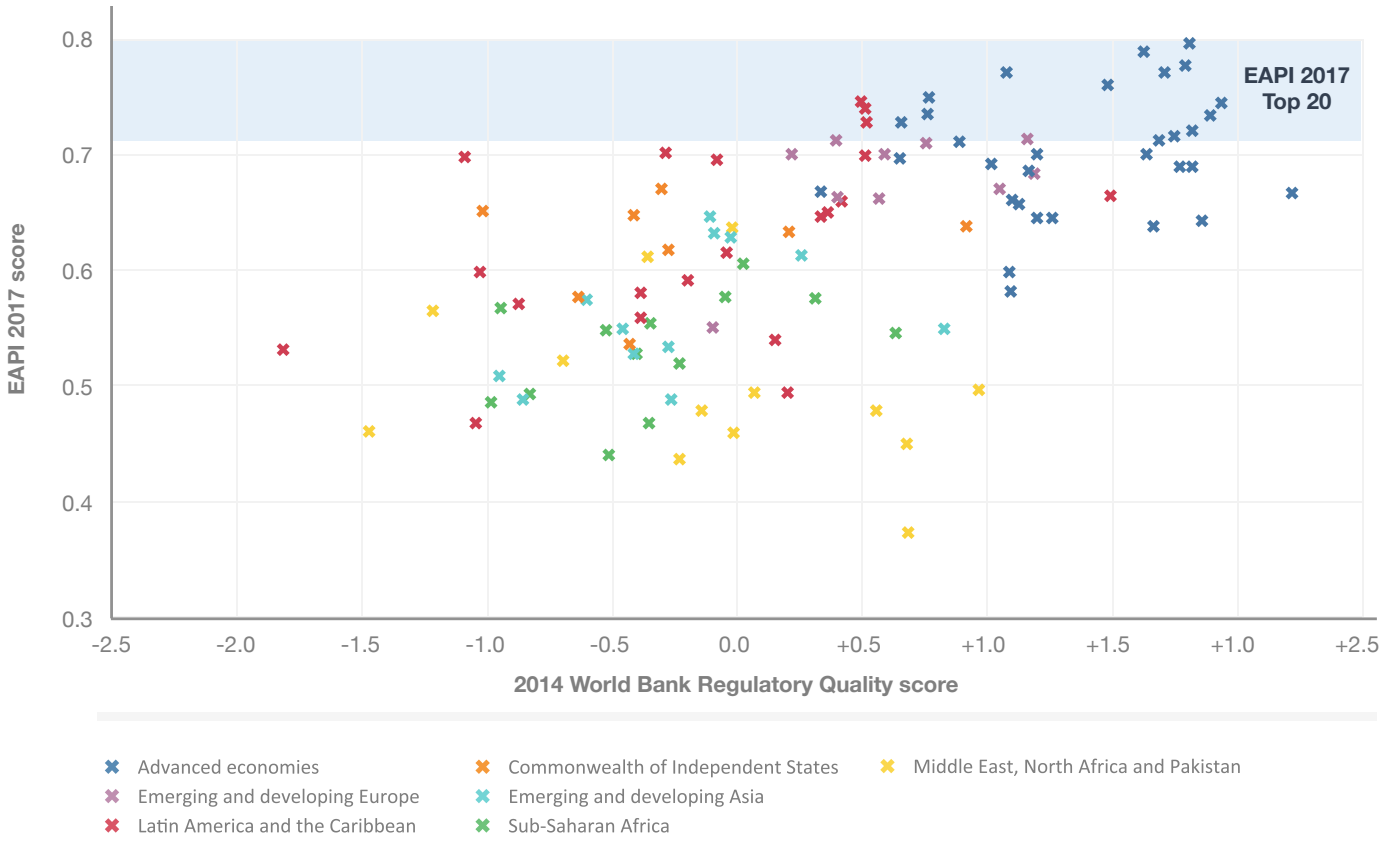
When formulating energy policy, energy sector goals should be aligned with other areas of the economy and related policies. This sets the right conditions for the energy transition, which itself is fuelled by innovation and evolving technologies. Effective energy-sector policies help support this innovation without picking technology winners, allowing the most appropriate solutions to emerge organically. One of the 10 fundamental elements of **Jamaica**'s long-term strategic vision for its energy sector is that it should have "the flexibility and creativity to adopt and adapt to new and appropriate energy technologies … that may emerge over the long term" (21).

Stakeholder groups operating in silos will not create a successful transition. While governments formulate the policies, other stakeholders are ultimately relied on to implement the changes and achieve the goals they direct. To implement policies effectively, however, good policy design involves the implementing institutions and end-users to

rigorously test policies and assess their feasibility. Through this process, the formulators and executors build an important sense of joint-ownership ahead of implementation, instilling clear understanding of the policies' intent among all parties.

Mexico's reforms have required significant institutional development to ensure that stakeholders are aligned to the objectives. Notably, Pemex, the state-owned oil company, is migrating to a model closer to that of a private-sector company, while the electricity sector has opened up to private investment (mainly in generation) in some stages of the value chain. The government additionally created new regulatory agencies, and significantly increased the budgets of others – fivefold in some cases – so that reforms could be more easily implemented.

Figure 8: The compelling link between well-designed policies and high performance on the EAPI



Source: World Economic Forum and Accenture analysis

Sweden's central government leads energy policy design, with support from several implementing national and local authorities. The government gives administrative boards the mandate to formulate regional energy and climate strategies and to represent it at the regional level, in collaboration with regional actors (22).

Uruguay laid the foundations for successful policy design in 2005 by creating an interministerial coordination group, which brought together all national entities involved in the policy-making process to start a dialogue on energy policy goals. At least 11 institutions are involved in the process, ranging from ministries focused on agriculture to sports and tourism. This broad dialogue and coordination among stakeholders has been critical for effective policy design, with clear mandates and a sense of shared ownership creating the conditions for successful implementation. Cooperation with UTE and ANCAP throughout the policy-design process had also been a key success factor for implementation.

3. Steward investment to the most impactful areas

Significant investment is required to make progress on the energy transition and meet growing energy demand. The IEA estimates that $48 trillion in investment is needed globally to meet energy needs to 2035 (11). To invest with confidence, industry will need stable policy regimes to allay both the regulatory risk of the initial investment and the refinancing risk. National elections will likely occur during the long lead times involved, as well as several changes of government over the investment's operating life. Policy support is thus required not only from the incumbent government, but also through a long-term strategy with broad-based political support. **Jamaica**'s long-term vision and expressed commitment are complemented by many opportunities for private-sector companies to invest in its energy sector, including a deregulated generation environment, a liberalized fuel sector and opportunities for commercial hydrocarbon exploration.

Private-sector investment requires stewardship to ensure it focuses on the right areas. Choosing the right public-private-sector partnership models is important to promoting investment that focuses on areas best serving the overall vision. In some cases, the need for investment means opening up historically publicly monopolized energy sectors to the private sector, as **Mexico** has done successfully with its oil and gas and electricity sectors.

Innovative approaches are required to ensure investment is stewarded to maintain an attractive environment for investors. This was achieved in **Uruguay** by framing private projects within contracts with public companies. Other tools include target setting, bidding processes and long-term contracts. More conventionally, the country is also ambitiously promoting offshore exploration to find and develop potential domestic hydrocarbon resources. Within **Jamaica**'s liberalized generation market, the government has issued requests for proposals for energy plants to add capacity to the national grid, specifying the range of renewable technologies that could be used (23). The construction of **France**'s nuclear-dominated energy sector, which began in earnest in the 1970s, was financed with a mix of commercial loans and investment from financially strong and vertically integrated state-owned utility companies, such as Électricité de France.

More recently, as the country looks to diversity its energy mix with renewables, a number of steps have been taken to secure the investment required to drive this transition, including simplifying administrative procedures, increasing the number of calls for tender, improving financing conditions, and supporting French industry and the emergence of innovative technologies (24).

The early deregulation of **Sweden**'s electricity markets in 1996 helped to unlock the private investment required to drive the technological innovation underpinning much of sector's efficiency today. Sweden was the first country to install smart meters for its customers (in 2009). It also collaborates with Norway to issue green electricity certificates to producers as part of a market-based support scheme designed to boost renewable electricity production in both countries. The scheme is technology-neutral, with all forms of renewable electricity entitled to certificates. By creating demand through government-imposed quota obligations, it establishes the certificates' value, which means the market determines the price of electricity certificates and which projects are developed. Producers of renewable electricity gain additional income from selling certificates, which increases the attractiveness of developing new electricity production based on renewable sources (25).

Mexico's recent structural reforms have developed new special investment vehicles designed to spur investment in energy assets and a wider range of industries. Fibra E allows the state-owned productives to monetize revenue streams arising from mature energy and infrastructure projects, to some extent replicating the master limited partnerships which fuelled the US shale boom. Additionally, Investment Projects backed Certificates (CerPI) a new investment vehicle for private equity with flexible corporate governance, is designed to attract top local and international institutional investors. The Mexican government has also engaged in significant public policy and development by creating scholarships and training to study energy-related disciplines, investment within non-profit institutions and the promotion of domestic energy-related industry. These are strong examples of being inspired by successful methods in other countries and reinterpreting them so they align with a country's own national interests. In addition, the Mexican Senate has agreed a comprehensive range of fiscal regimes for international oil companies and service providers to attract international investment and participation.

Uruguay, Mexico, Jamaica, Sweden and **France** exhibit many differences, from the scale of their geographies, populations, economies and energy sectors through to the composition of their primary energy supplies and endowment of natural resources. This diversity is indicative of the huge range of contexts across the EAPI's 127 ranked countries. Accordingly, the five countries show many differences in how they have steered their energy sectors through transition, as demonstrated by the wide breadth of the examples.

But despite these differences, their journeys revealed three common underlying principles worthy of consideration by any country looking to emulate their transitions:

– Setting a frame for the long-term direction of the energy sector, and committing to it, will help bring greater balance to the energy triangle and enable an effective transition in the long term.
– Enabling the energy transition with adaptable, co-designed policies will support the sustainability of energy policies.
– Stewarding investment to the most impactful areas unlocks and focuses the capital required to fuel the transition.

These principles are mutually reinforcing, building on each other to allow for robust energy architectures that provide affordable, secure and sustainable energy.

Concluding remarks

The results of the *Global Energy Architecture Performance Index Report 2017* reveal nuances in the transitions of the world's energy systems. While advanced European economies still hold many of the top ranks on the EAPI, countries outside this peer group are amply represented. This suggests that any country has the potential to provide secure, affordable and sustainable energy to its population, regardless of the size of its economy, its level of advancement, geographical region or exporter status. In fact, examining the history and ongoing transitions of some of the EAPI's high performers, as well as those of countries that have made big step changes in performance over the past eight years, indicate commonalities among all their differences. These take form in three principles of energy-sector governance. Under these principles, the paths the countries take to steer their sectors through transition are marked by differences. These differences, in turn, highlight that every country needs a tailored approach to suit its unique context while seeking to fulfil the same ultimate goal: namely, a more sustainable, affordable, secure and inclusive energy system.

Underneath the perceived inertia of the global energy system, the EAPI highlights some significant movements of individual countries and reveals progress on the energy transition. Similarly, it calls attention to the challenges countries continue to face. Energy architecture is large and complex, and enormous legacy systems remain in place. The scale and complexity involved will require that stakeholders take an incremental approach, particularly if they are to manage the economic impact of writing down legacy assets. The transition continues to require sustained efforts and deep collaboration between the public and private sectors over the long term, in order to evolve energy systems for the better.

Appendices

Addendum on methodology

This section presents the methodology for the global Energy Architecture Performance Index (EAPI) 2017. A more detailed description of the methodology is available online at http://wef.ch/eapimethodology. The EAPI is a composite index that measures a global energy system's performance across the three imperatives of the energy "triangle": (i) economic growth and development, (ii) environmental sustainability and (iii) energy access and security.

Methodology overview

The EAPI focuses on tracking specific and output-oriented indicators to measure the energy system performance of a variety of countries. It includes 18 indicators, aggregated into three baskets relating to the three imperatives, to both score and rank the performance of each country's energy architecture. The EAPI is split into three sub-indexes. The score attained on each sub-index is averaged to generate an overall score. The three sub-indexes are:

1. Economic growth and development: The extent to which energy architecture supports, rather than detracts from, economic growth and development
2. Environmental sustainability: The extent to which energy architecture has been constructed to minimize negative environmental externalities
3. Energy access and security: The extent to which energy architecture is at risk of an energy security impact, and whether adequate access to energy is provided to all parts of the population

Indicators: Selection criteria and profiles

Where possible, the EAPI team aimed to select indicators against the following criteria:

- **Output data only:** Measuring output-oriented observational data (with a specific, definable relationship to the sub-index in question) or a best-available proxy, rather than estimates
- **Reliability:** Using reliable source data from renowned institutions
- **Reusability:** Sourcing data from providers with which the EAPI can work on an annual basis, thus allowing for data to be updated with ease
- **Quality:** Selecting data that represents the best measure available given constraints; with this in mind, all potential data sets were reviewed by the Expert Panel for quality and verifiability, and those that did not meet these basic quality standards were discarded
- **Completeness:** Using data of adequate global and temporal coverage, consistently treated and checked for periodicity to ensure the EAPI's future sustainability

Where data is missing for a particular year within an indicator, the latest available data point is extrapolated forwards until a more recent result is obtained.

Key adjustments for EAPI 2017

The aim is to keep the methodology consistent with previous years' reports for year-on-year comparison. However, minor adjustments are made to reflect issues such as discontinuation of data and improvements to the model. The key adjustments to this year's report are:

- Normalization: Minor adjustments have been made in normalization scores.
- Extreme values removed: For example, the electricity price for Italy has been removed following reviews of PX-Web databases of ENEL, the Italian electricity company.

Indicators profile

Figure A.1 details each of the indicators selected, the weight attributed to it within its basket (or sub-index), what it measures and the energy system objective that it contributes to, either positively or negatively.

Figure A1: EAPI 2017 indicators and weight

Energy system objective	Measure (of)	Indicator name	Indicator weight
Economic growth and development	Intensity	Energy intensity, GDP per unit of energy use (PPP $ per kg of oil equivalent)	0.25
	Supports/detracts from growth	Cost of energy imports (% GDP)	0.125
		Value of energy exports (% GDP)	0.125
	Affordability	Degree of artificial distortion to gasoline pricing (index)	0.125
		Degree of artificial distortion to diesel pricing (index)	0.125
		Electricity prices for industry ($ per kWh)	0.25
Environmental sustainability	Ratio of low-carbon fuel sources in the energy mix	Alternative and nuclear energy (% of total energy use, incl. biomass)	0.2
	Emissions impact	CO_2 emissions from electricity production, total gCO_2/kWh	0.2
		Methane emissions in energy sector (metric tonnes of CO_2 equivalent)/total population	0.1
		Nitrous oxide emissions in energy sector (metric tonnes of CO_2 equivalent)/total population	0.1
		PM2.5, country level (micrograms per cubic metre)	0.2
		Average fuel economy for passenger cars (l/100 km)	0.2
Energy access and security	Level and quality of access	Electrification rate (% of population)	0.2
		Quality of electricity supply (1-7)	0.2
		Percentage of population using solid fuels for cooking (%)	0.2
	Diversity of supply	Diversity of total primary energy supply (Herfindahl index)	0.1 / 0.2 [7]
	Self-sufficiency	Import dependence (energy imports, net % energy use)	0.2
		Diversification of import counterparts (Herfindahl index)	0.1 / 0 [8]

[7] For the indicator on diversity of total primary energy supply, net exporters are given a weight of 0.2 (since they are not scored for the indicator on diversification of import counterparts), whereas net importers are given a weight of 0.1 to form a mini-index for diversity of supply

[8] The indicator on diversification of import counterparts only applies to net importers: for these countries, a weight of 0.1 is used (for net exporters, a weight of 0 is used)

Weights, measures and abbreviations

$	All $ in US$ unless otherwise noted
CerPI	Investment Projects backed Certificates
CH_4	Methane
CO_2	Carbon dioxide
COP21	United Nations 21st Conference of the Parties
EAPI	Energy Architecture Performance Index
EU	European Union
EU28	28 Member States of the European Union
g	Gram
GDP	Gross domestic product
GIZ	German Federal Enterprise for International Cooperation
HHI	Herfindahl-Hirschman Index
IEA	International Energy Agency
kWh	Kilowatt-hour
LNG	Liquefied natural gas
N_2O	Nitrous oxide
OECD	Organisation for Economic Co-operation and Development
PM2.5	Particulate matter less than 2.5 micrometres in diameter (also called “fine particles”)
PPP	Purchasing power parity

Endnotes

[1] Based on an average price of Brent crude per barrel, $111.26 in 2011 (32) and $44.95 in 2016 (January to October) (28).

[2] Planned capital investment from 2015 to 2020, including conventional exploration investment (26).

[3] Ten of the biggest global utility companies, measured by market capitalization, are: Duke Energy, Engie, National Grid, Next Era, Enel, Dominion Resources, Iberdrola, Southern, Exelon and Transcanada (29).

[4] In accordance with latest available data from the World Bank, 2014 (27).

[5] The vision as laid out in the Energy Policy 2005-2030 is to "satisfy energy requirements, at accurate and competitive costs, promoting good energy consumption practices towards energetic independence, in the framework of regional integration, using energy policy as an instrument to develop productive capacities and to promote social integration" (30).

[6] The Regulatory Quality Indicator, part of the World Bank's set of worldwide governance indicators, is formed from sources that measure concepts such as unfair competitive practices, price controls, discriminatory tariffs, the effectiveness of anti-trust policy, investment and financial freedom, ease of starting a new business, regulatory burden and tax inconsistency (31).

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World Economic Forum
91–93 route de la Capite
CH-1223 Cologny/Geneva
Switzerland

Tel.: +41 (0) 22 869 1212
Fax: +41 (0) 22 786 2744

contact@weforum.org
www.weforum.org