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Policies for the future

2011 Assessment of country energy and climate policies

World Energy Council

Project Partner
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Foreword by Pierre Gadonneix

It gives me great pleasure to unveil this 3rd edition of our annual review of country energy policies and practices.

This new edition comes at just the right time, after a bumpy 2011 marked by events that have created turbulence in the energy sector worldwide.

However, we should remember that each year brings its own challenges and opportunities: be they industrial, economic, geopolitical, unexpected technological breakthroughs or new geological discoveries, among others. The year 2011 has certainly seen major changes, with, in particular, the accident at Fukushima and the Arab Spring. But 2010 was also significant, with the ongoing development of shale gas, confirming it as a 'game-changer', and the accident in the Gulf of Mexico. And who can predict what 2012 has in store?

Nevertheless, if we take a moment to observe the energy landscape beyond the confusion of the daily news, we can see that we still face major long-term challenges. Our 'energy trilemma' requires us to act decisively on three fronts:

- Providing 7 billion people (9 billion in 2030) with the secure energy needed to fuel economic development. This means huge investments, totalling 1.4% of global GDP per year by 2030, which will have to be made on time and on budget.
- Protecting our climate and environment, which means reducing global CO_2 emissions by a factor of four by 2050, preserving water and air quality, especially in cities, and ensuring the safety of all our energy infrastructure.
- Promoting social equity and universal access to energy, at a time when 2 billion people in the world still do not benefit from modern energy. This question will be critical in the future. Appropriately, 2012 has been named the 'International Year of Sustainable Energy for All' by the UN.

In order to rise to our three challenges, the global energy sector needs a resilient system. A system that allows us to pursue, year after year, our long-term objectives and at the same time is flexible enough for us to capitalise on unexpected opportunities and 'game changers' and overcome unforeseen obstacles.

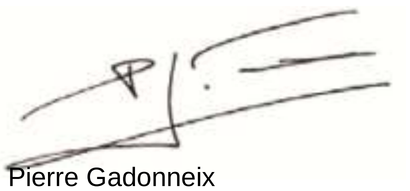
Such a system will rely on the strengths of both markets and smart regulatory frameworks. Markets alone cannot succeed, but public policies can also fail to deliver.

This is why WEC's annual review of country energy policies and practices is a significant resource for national policymakers as they aim to achieve the best-possible solution to the energy trilemma for their countries. Our aim is to help shape a deeper understanding of the policy instruments that they can leverage in different sectors – this year, our focus was on energy efficiency, transport and financing mechanisms – and at different levels (national, regional).

Beyond the diversity of regulatory instruments, certain keys to success never change when designing a smart regulatory framework for energy. The core components are:

- A long-term vision, based on real costs (including an implicit CO_2 value), which fosters confidence in public and private investors. The investments needed are huge. Developing countries need to build infrastructure and keep up with demand (85% of energy demand growth comes from emerging and developing countries). But investments are also vital in developed countries, to maintain and renovate older infrastructure. This is all the more important as price volatility is high and generates great uncertainties.
- A balanced system involving all sources of energies, building on available and mature technologies while at the same time preparing for the technologies and competencies of the future. We cannot stress enough the importance of such a balanced system. The year 2011 proved again that all sources of energy are sensitive to geopolitics and no technology is risk-free. Technologies may be competitive in one region and yet far too expensive in another, or in a different cultural context, as is the case for some energy efficiency measures. Looking closely at a technology's merit order country by country and promoting a balanced mix is key. Preparing for future skills and industries in advance is also crucial.
- A strong commitment to building dialogue and promoting the acceptability of all energies and technologies. Acceptability encompasses many dimensions that need be considered not only within national frontiers, but globally, through renewed international governance. Safety is one example of course, but so are environmental and climate protection, energy poverty, and the impact of policy on the local economic context and national competitiveness.

What I call real governance begins right here, with all WEC members. If we are to rise to all our challenges, the energy sector will need strong leadership. All of us have an opportunity to play a key role, and WEC can be the catalyst in building dialogue, sharing feedback from experience and fostering a clear vision among energy leaders. This WEC review is part of that process, providing tools and insight to contribute to a genuine analysis of country energy policies and practices.



Pierre Gadonneix
Chair World Energy Council

Foreword by Joan MacNaughton

Energy policy affects everything we do, from issues of national concern such as national security, economic development, and sustainability, to more mundane aspects of our daily lives such as our access to power and fuels and the effect on our immediate environment. Over the last few months we have been reminded of this fundamental truth in the most dramatic fashion. Natural and man-made disasters have interrupted supplies and called into question the ways we supply and consume energy.

The markets which deliver our energy are affected by the frameworks in which they operate: government policies are immensely influential, determining how we source, refine, convert, distribute, supply and consume energy. Even where primary fuels remain internationally traded commodities and where power is supplied and traded through markets, the actions of participants in those markets—business and consumers—will be determined to a greater or lesser extent by government policy.

This brings me to the first part of this WEC Policy Assessment in which we publish our Energy Sustainability Index. The Index ranks countries according to the stability, affordability, and environmental sensitivity of their energy systems. European countries have a strong presence in the topmost ranks, occupying seven of the places in the top ten. This may well be because European countries have been at the forefront of international action to address climate change, recognising not only their duty to the Earth's ecosystem, but also the competitiveness advantages to be gained by occupying 'first mover' status in developing tomorrow's clean technologies. I hope that the Index will inspire and inform, offering useful examples of best practice that can be replicated.

Governments must also recognise that by intervening in markets, they may create uncertainty and unintended consequences. The deadening impact of policy uncertainty on investment was highlighted in last year's Policy Assessment. The lessons are valuable and applicable to all areas of policymaking.

Certain lessons emerge:

- Policy must be evidence-based and rooted in robust, independent analysis of the issues it seeks to address and of the original objectives of the policy intervention.
- Transparency is vital to help business and consumers to understand the trade-offs that may be involved in adopting certain policies and their broader implications.
- This should also imply high standards of consultation and public engagement. This is to ensure that draft policies are subjected to rigorous and broad-based assessment, as well as giving those who will be affected by them enough notice to prepare themselves to adapt and comply.
- Finally, implementation of the policy must be monitored to ensure that it is delivering as intended, including ensuring consistency across policy dossiers. Here it is vital that governments are able to balance the need to provide markets with long-term policy stability against the necessary flexibility to adapt and change policies that are clearly failing to

achieve their objectives. Striking this balance is one of the most difficult aspects of policymaking. But it can be made easier where governments have clearly signalled their overall direction of travel by setting clearly-defined targets, and where their public engagement has been thorough and conducted with sufficient information about their intentions.

As we approach the UN's Conference on Sustainable Development in 2012 in Rio, these issues take on additional importance: they will determine to a large extent the ability of emerging and developing countries to set policy frameworks that will build markets and attract private investment. Only by doing this can all governments attract the investment necessary to enable sustainable growth. Developed countries, international institutions, and business can play a role in helping developing countries to build the policy frameworks to achieve this.

Ensuring investment on the scale needed to transform for sustainability the way we produce, transport, and use energy and to provide energy services to the 1.4 billion people without them is a daunting global challenge. I commend the WEC policy assessment to policymakers and the business and investment community as an important contribution to meeting it.

Joan MacNaughton
Executive Chairman, WEC Policy Assessment

Executive Summary

To provide energy systems that are simultaneously affordable, stable and environmentally sensitive is the universal aspiration. If the enabling policies are to gain acceptance, promote investment and secure our energy future, they should be built on transparent dialogue that is explicit about the trade-offs between multiple goals, time periods and participants, necessary to overcome this 'energy trilemma'.

The earthquake and huge tsunami at the Fukushima Daiichi nuclear power plant, Japan, in March 2011, has re-invigorated the debate on how to meet the world's growing demands for energy.

The challenges are numerous. Energy must be accessible and affordable, contribute to the well-being of people and the environment, and enhance economic growth now and for the future. Policymakers must accommodate these multiple requirements while reducing the carbon intensity of energy.

Three dimensions of energy sustainability

The World Energy Council (WEC) definition of energy sustainability is based on three core dimensions—energy security, social equity, and environmental impact mitigation. The development of stable, affordable, and environmentally sensitive energy systems defies simple solutions. These three goals constitute a 'trilemma', entailing complex interwoven links between public and private actors, governments and regulators, economic factors, national resources, environmental concerns, and the behaviours of individuals.

Energy Sustainability Dimensions

- *Energy security.* For both net energy importers and exporters this includes the effective management of primary energy supply from domestic and external sources; the reliability of energy infrastructure; and the ability of participating energy companies to meet current and future demand. For countries that are net energy exporters, this also relates to an ability to maintain revenues from external sales markets.
- *Social equity.* This concerns the accessibility and affordability of energy supply across the population.
- *Environmental impact mitigation.* This encompasses the achievement of supply- and demand-side of energy efficiencies and the development of energy supply from renewable and other low-carbon sources.

The World Energy Council's *2011 Assessment of country energy and climate policies* report explores the energy challenges facing policymakers and energy-industry executives.

First, the report presents the Energy Sustainability Index. The Index ranks WEC member countries in terms of their likely ability to provide a stable, affordable, and environmentally sensitive energy system.

Second, this year's report focuses on three themes related to the pursuit of energy sustainability and associated policies: addressing the demands of energy and mobility; pursuing energy efficiency; and implementing innovative financing mechanisms for the maintenance and replacement of existing infrastructure and the development of new energy infrastructure. The analysis was supplemented by the perspectives of energy-industry executives and WEC member committees, captured through surveys, direct interviews, and meetings.

Figure 1

Energy Sustainability Index leaders (by economic groupings)

Source: Multiple (IEA, EIA, World Bank, IMF, WEF etc. 2009-2010)

	GDP/capita (USD)	> 33,500	14,300 – 33,500	6,000 – 14,300	< 6,000
Positioning	1	Switzerland	France	Colombia	Philippines
	2	Sweden	Japan	Latvia	Indonesia
	3	Germany	Spain	Brazil	Swaziland
	4	Canada	Finland	Mexico	Cameroon
	5	Norway	Italy	Albania	Sri Lanka

Black font = net energy importers. Blue font = net energy exporters

Energy Sustainability Index

The Index displays the aggregate effect of energy policies applied over time in the context of each country. It is based on an empirical analysis of a range of indicators that reflect the three goals of energy sustainability. These include energy performance indicators across the WEC energy-sustainability dimensions, and contextual indicators that reflect the broader political, social, and economic circumstances of the country. Figure 1 shows the strongest performers in the 2011 Index.

The Energy Sustainability Index highlights that all countries face an imbalance amongst the three dimensions of energy sustainability. As countries develop and economies mature, they make choices that tend to strengthen or trade-off one or two dimensions against the third. Despite differences in resource endowment and market structure, leading countries, mostly mature economies, show low energy-demand growth and robust policy environments. These are supported by well-established energy-efficiency programmes, and a balance between affordable energy and pricing that enables investment.

Sustainability therefore involves a shifting balance of trade-offs between the three dimensions of energy sustainability with no single ‘silver bullet’ formula. Each country must determine its balance, taking into consideration its needs, public acceptance, and key externalities.

Takeaways on the Energy Sustainability Index

- Policy choice is a key discriminating factor of energy performance.
- High-energy resource endowment does not necessarily result in long-term energy security. This is also dependent on economic, social, and environment choices.
- National resources, wealth, and contextual performance are not the dominating factors driving country energy-sustainability performance. When it comes to policy implementation to support energy sustainability, each country needs to determine its unique trade-offs.
- Energy security can change quickly in the short-term through minor policy adjustments, but long-term energy security can also be eroded by the implications of strategic decisions, such as over-reliance on energy commodities, lack of diversification of energy assets, and lack of energy autonomy.
- Social equity and efforts to mitigate environmental impacts, based on policy signals or energy-regime developments, often require several years to take effect.

Policy analysis

The energy system is the source of approximately 60 per cent of total current greenhouse gas (GHG) emissions. The report therefore focuses on policies relating to three critical issues where governments are able to take decisive steps to meet and dampen rising energy demand while working to limit the growth in CO_2 emissions. The polices studied this year are driving changes in mobility patterns and associated energy use, encouraging energy efficiency, and supporting innovative financing mechanisms for much needed energy infrastructure.

Mobility and energy

The mobility and transport of goods and people is critical for economic development and social cohesion. Passenger transportation represents the largest proportion of world transport fuel consumption, and by 2035 it is predicted to consume 90% of the world's total liquid fuel consumption. Transport is the fastest-growing source of global carbon emissions[1] and is responsible for a range of social and environmental problems, including local air pollution, noise, road congestion, and accidents. As the global population increasingly clusters in urban centres, sustainable urban mobility represents a key target of energy policy.

The reviewed policies highlight the importance of a long-term economic and social vision for sustainable transport. Private vehicle ownership is still the preferred mode of transport for many people—and in some situations the only option for effective mobility. Reducing CO_2 emissions from transportation will require important policy choices, significant investment, and changes in behaviour. The neglect of public transport can encourage the development of car-dependent infrastructures and adoption of lifestyles that can be very difficult to reverse. Government policies can positively influence oil consumption in road transportation by applying efficiency standards, promoting efficient technology, and giving incentives for desired consumer behaviours.

The policies reviewed demonstrate that it is possible to design transport and mobility policies that make a real contribution to environmental and social objectives. Above all, it is essential to supply integrated packages of mutually supportive measures focusing on user convenience, so as to increase the appeal of sustainable transport infrastructures. Similarly, consultation and collaborative dialogue with the public and private sectors are essential for building public support and facilitating behavioural change.

Energy efficiency to optimise resources

Energy efficiency is widely recognised as a key mechanism to achieve progress towards a lower-carbon economy. Energy efficiency can also contribute to social equity by reducing energy prices and increasing energy availability. Promoting energy efficiency is widely viewed as being the largest, cheapest, and fastest option for tackling key energy problems, and many solutions are available already.

But challenges remain. Energy efficiency can be expensive and entail transaction costs that are hard to measure and reduce. Attracting financing for energy-efficiency initiatives and encouraging consumers (residential and industrial) and energy suppliers to adopt existing solutions is one of the biggest challenges facing energy policymakers—especially when the payback periods are long. An associated challenge is the evaluation of the effectiveness of expenditure on energy efficiency. Measurement and verification techniques are essential tools when complex and variable systems are involved.

Moreover, it is essential to assess and include the rebound effect on efficiency programs as part of the policy design. A recent study by the European Union highlighted that as much as 30% of the gains from energy efficiency are lost because the savings are put back into energy-consuming activities. For example, more efficient automobiles result in people driving longer distances, which means there will be very little improvement in the total amount of energy used and CO_2 produced.[2]

The energy-efficiency policies examined in this report underscore the need for policymakers to consider consumer (and corporate) behaviour as much as technologies. Successful policies apply a combination of information, awareness, and incentive programmes to overcome market and non-market barriers to implementing energy-efficiency mechanisms. Energy-efficiency policies must evolve over time to ensure initial achievements can be sustained, reflecting the development of technology and markets. Finally, policymakers must be mindful of rebound effects, in order to ensure energy savings in one area (e.g., personal transport) are not undone by increased energy use elsewhere—either by direct (e.g., driving more and further) or indirect (e.g., increased consumption of goods) energy use.

Financing energy infrastructure

Approximately 1.4% of global GDP will need to be invested each year in energy-supply infrastructures to 2035 to meet growing demands and increased energy access in developing countries.[3] Our report examines a range of financing instruments that address these challenges, as well as the issues involved in maintaining existing supply infrastructure, ensuring the reliability of supply, and promoting the development of new low-carbon energy infrastructure.

The analysis highlighted the fundamental importance for investors of well-defined and stable energy policies with reasonable predictability of financial outcomes over several decades. Governments and public bodies play an important role in designing and implementing rules and supporting the necessary range of market and financing arrangements to stimulate investment. Indeed, through policy stability, effective communication, and well-defined roles and responsibilities, governments can reduce the risks of regulatory change and other policy-driven investment uncertainties which otherwise may inhibit investments. This, in turn, will optimise the private sector’s ability to bring forth capital in public/ private partnerships.

Finally, both industry and government must engage in dialogue with citizens to ensure that the public funding of energy infrastructures, energy efficiency, and the transition to low-carbon energy systems is sustainable, equitable, and credible.

The key messages for policymakers from the *2011 Assessment of country energy and climate policies*, which cut across all policy areas, are set out below.

Key messages for policymakers

Assess, communicate and manage policy trade-offs

- Energy policymaking is complex, with multiple objectives that cannot always be pursued simultaneously.
- Policymakers must be transparent and explicit about the trade-offs involved in a policy and about the rationales for the choices they make.
- The introduction of new policy instruments on top of existing policy instruments must be analysed in advance to avoid potential conflicts, redundancies, and policy failures.
- Policies must be continuously monitored to identify and address unintended consequences.

Address complexity and co-ordination across multiple jurisdictions and energy-policy domains

- Multiple levels of government are involved in aspects of energy policy, each with its own responsibilities, competences, and opportunities to contribute to sustainable energy policy.
- To achieve policy objectives co-ordination is needed across at least three dimensions: policy instruments, jurisdictions, and local, regional and national government levels.

Adapt 'best practice' policy instruments:

- Dialogue with international energy-policy experts, policymakers, industry, and stakeholders can provide reliable evidence on what works and possible pitfalls.
- Countries must translate global findings about successful policy instruments into local arrangements and settings.

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Conclusion

It is estimated that energy demand will rise by 40% over the next 20 years, primarily in developing countries. The drivers include population growth, the enormous, on-going industrialisation process, the continuing relocation of industrial production to Asian countries, the expansion of transportation infrastructure, and the advancing affluence of a currently small, but fast-growing middle class in those countries. At the same time, an estimated 1.4 billion people currently lack access to electricity and 3 billion people rely on traditional biomass fuels for cooking, heating, and other basic household needs.[4]

Progress is being made towards a lower-carbon energy supply. For example, global investment in renewable energy in 2010 was a record $211 billion, up 32% over 2009.[5]

However, much needs to be done in order to deal with the trilemma of energy sustainability. In developing stable, affordable, efficient, and environmentally sensitive energy systems, policymakers and the energy industry must address three critical tensions:

- Ensuring a stable regulatory regime that supports a large volume of capital, investments while allowing policy updates and revisions as necessary
- Driving changes in energy systems at a pace that may be faster than markets alone will support
- Stimulating an urgency to reduce carbon emissions and the policies to drive those changes, while building and maintaining support from consumers and citizens

The *2011 Assessment of country energy and climate policies* highlights the tremendous value of international dialogue about the pursuit of sustainable energy solutions. This is especially the case at this critical juncture in global policymaking, when hard choices have to be made and multiple benefits secured. Policymakers and industry must work together to design and implement broadly supported mechanisms to address energy sustainability in the near and long term. As its policy assessment work continues, WEC will look to facilitate such interactions among policymakers and the energy industry, aiming to deepen the current extensive exchange of ideas on the national, regional, and international levels.

Introduction

World Energy Council policy assessment

This report is the third annual assessment of energy policymaking across the globe by the World Energy Council (WEC). The goal of this report is to provide policymakers with a comparative ranking of their countries' ability to provide a stable, affordable, and environmentally sensitive energy system, and to offer insights and lessons on effective energy-sustainability policies.

The report findings are based on three sources of research: empirical data analysis supporting the Energy Sustainability Index, surveys of energy-industry executives and WEC member committees, and an in-depth analysis of selected country energy policies.

Consistent with previous reports, this report includes the results of the Energy Sustainability Index. The Index captures and aggregates country data to outline the relative energy performances and contextual attributes of WEC member countries. The Index thereby highlights current challenges relating to energy sustainability.

This year's report focuses on three themes relating to the pursuit of energy sustainability and the development of associated policies: energy and mobility, energy efficiency, and innovative financing mechanisms. The three topics were selected based on their importance in addressing key issues relating to global energy needs. These include the significant volume of liquid fossil fuels absorbed by road transport, the potential for energy-efficiency measures to affect future energy demands, and the need to finance new and diverse energy infrastructures and refurbish existing capital stocks.

The three themes are examined through detailed reviews of selected country polices. The policies were deliberately selected for their geographic coverage, the lessons and guidance they provide to policymakers, and the potential transferability of success measures. In terms of policy types, the research examined a wide range, including legislation, executive order, regulation, and voluntary target/agreement.

The policy analysis was supplemented by the findings of energy-industry executive and WEC member committee perception surveys. The survey asked complementary questions to the two communities to provide comparable insights on issues relating to urban mobility, energy efficiency, and innovative financing mechanisms.

Both the research and the formulation of the report's key messages have benefited from the extensive involvement of energy experts around the world. The World Energy Council conducted the overall project in partnership with the global management-consulting firm Oliver Wyman. The University of Sussex, UK, provided support for the country policy reviews. Representatives from WEC member committees served on a study group that guided the analysis and shaped the report's contents.

Further details on the project's participants and the supporting analyses can be found in the appendices.

2011 report

This report has six chapters. Chapter 1 examines the 2011 Energy Sustainability Index and Chapters 2, 3, and 4 explore policy lessons related to this year's key themes and conclude with a checklist for policy design and implementation. Chapter 5 summarises the lessons for policymakers and draws out the takeaways from the preceding chapters. Chapter 6 concludes the report and highlights key energy challenges facing us.

1. Energy Sustainability Index: context for policymaking in 2011

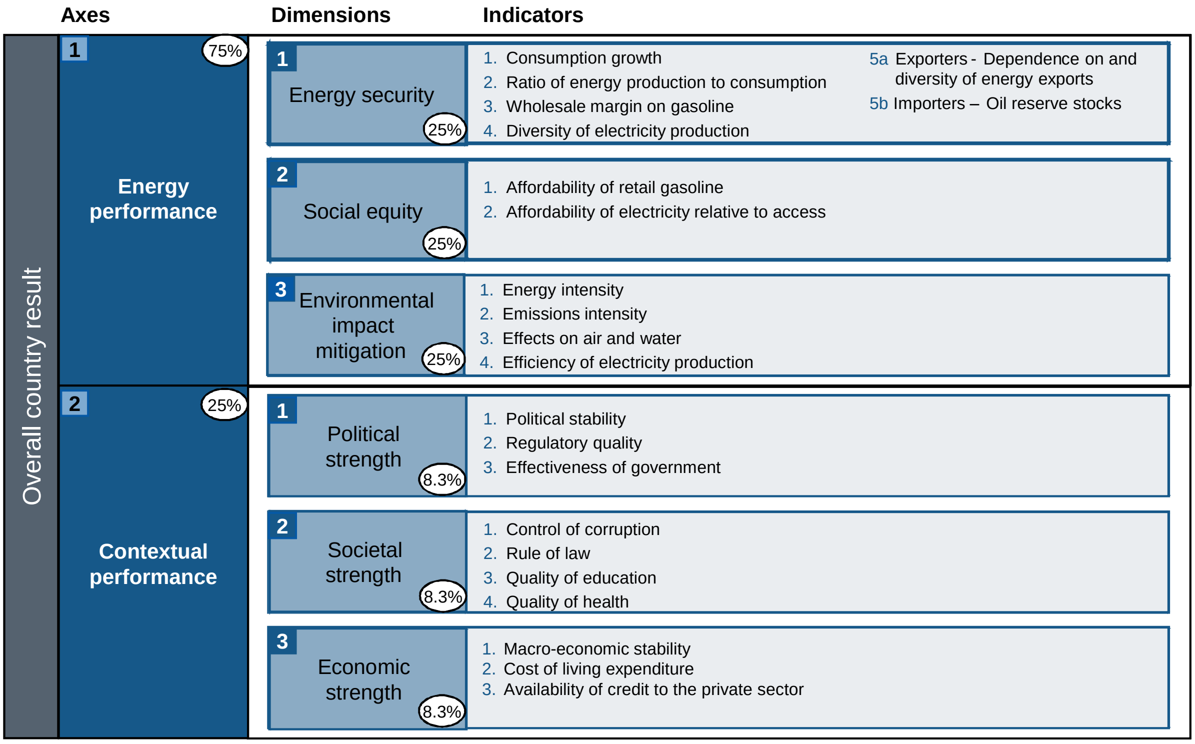
The Energy Sustainability Index ranks WEC member countries in terms of their likely ability to provide a stable, affordable and environmentally sensitive energy system. The rankings are based on a range of data and databases that capture both energy performance and the context of that energy performance. Figure 2 provides an overview of the Index structure and dimension weightings. Energy performance indicators consider supply and demand, the affordability and access of energy, and the environmental impact of the country's energy use. The contextual indicators consider the broader circumstances of energy performance including standards of living, and the economic and political climate.

These indicators were selected based on the high degree of relevance to the research goals; each is distinct, could be derived from reputable sources and captured for most WEC member countries. More details on the methodology, which is consistent with the 2010 assessment report, can be found in Appendix D.

Overall, the Index displays the aggregate effect of energy policies applied over time in the context of each country. It is very difficult to compare the effectiveness of particular policies across countries, since each policy interacts with a unique set of policies specific to that country. But it is possible to broadly measure the aggregate outcome of policies, for example, the level of country CO_2 emissions or the overall use of electricity per capita.

Figure 2

Index structure and weighting



Comparing country situations

The 2011 Energy Sustainability Index results are exhibited in Figure 4. Note that due to constraints on the collection, processing, and dissemination of data the current Index generally reflects data from 2009-2010. Recent world events that could affect the Index's outcomes are not captured (e.g., turbulence in global nuclear industry due to Fukushima, or the political unrest in the Middle East). Further, policies generally take two to three years to become fully implemented and it may take longer for their effects to become evident. Therefore, the Index does not exhibit significant shifts in country rankings from one year to the next. However, the 2011 Index already reflects early impacts of the economic crisis, and tremendous changes are likely to become visible in the next two years.

Nuclear continues to expand

Until recently nuclear power had been gaining traction and returning to the political and energy agendas of many countries. Nuclear power was again being seen as a crucial component of a sustainable energy mix due to the existing technology's ability to provide predictable and stable long-term generating costs, secure and consistent base-load capacity, and climate-change mitigation benefits.

The March 2011 disaster caused by a huge tsunami at the Fukushima Daiichi nuclear power plant in Japan has re-ignited public opposition and prompted a re-evaluation of the political appetite for nuclear power. European countries have responded very differently to these issues. Germany announced in May 2011 that it will phase out the country's 17 nuclear power stations by 2022. This decision makes Germany the biggest industrial power to announce plans to abandon nuclear energy. Likewise, Switzerland, which currently obtains about 40% of its energy from nuclear power, announced it will not replace its five nuclear plants once they reach the end of their lifetimes between 2019 and 2034. Japan is reviewing its plans to increase nuclear capacity. These changes may have impacts that transcend borders, since many countries (for example, Germany and Switzerland) receive electricity imports generated by nearby nuclear technology in a neighbouring country's jurisdiction.[6]

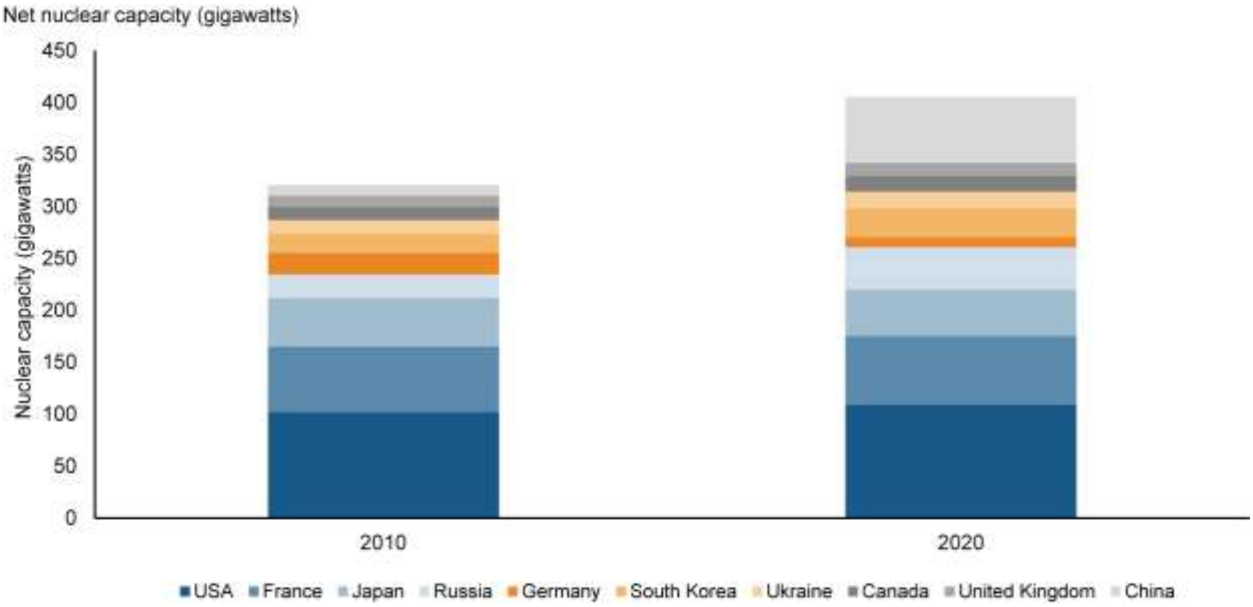
Despite some countries' retreat from nuclear energy, the overall global interest in it remains strong. Nuclear-energy capacity is expected to grow 27% over the period 2010-2020 as China, UK, USA, Ukraine, Korea (Republic) and others increase their capacity. In Europe, Germany's neighbour, France, which obtains three-quarters of its electricity from nuclear power plants, remains committed to nuclear as a means to secure energy independence. Poland has six nuclear power plants planned. Elsewhere, India is planning a significant reliance on nuclear energy, with a goal of establishing 30 reactors by 2050.

In moving forward with these plans, it is essential that the nuclear operators in all nations should assess the safety of their nuclear plants, and reflect on their current expertise, regulations and other lessons learned from the Fukushima accident. Indeed,

Figure 3

Nuclear capacity growth 2010-2020

Source: The Future of Nuclear Energy: One Step Back, Two Steps Forward, Economist Intelligence Unit, June 2011



in the face of recent events, the majority of nuclear nations seem to be committed to enhancing the regulation and safety of nuclear technology, as well as international cooperation on safety and acceptability.

How to replace nuclear?

The aftermath of Fukushima is causing a great deal of turbulence for the future of nuclear power in several regimes. The nuclear states looking to phase out nuclear technology must address the issue of how to do so without negatively impacting existing energy sustainability. For example, nearly one-quarter of Germany's electricity is currently provided by nuclear power. It will be challenging to fill the gap left by nuclear power while not increasing reliance on carbon-based power generation especially since the renewable infrastructure currently does not have the capability to do so. It is imperative that policymakers and industry executives have a clear, robust, and well communicated energy vision that considers all aspects of a nuclear phase out before instigating a wholesale change of a nation's energy mix including the impact on neighbouring countries and energy markets.

Figure 4 also shows the range of each country's potential ranking in the Index—as indicated by the width of the country-position slider. Countries with smaller slider bars, e.g., France or Spain, indicate more balanced scores across the underlying Index dimensions. Countries with larger slider bars show a greater imbalance between the dimensions and tend to be dependent on individual dimensions to drive their overall Index score. An improvement or deterioration in any of the dimensions can therefore lead to a significant change in a country's overall ranking and therefore in the magnitude of its country-position slider.

Any asymmetry in the slider bars indicates how changes to the underlying dimensions weights would tend to influence a country's position up or down in the overall Energy Sustainability Index. For example, any minor adjustments to the underlying dimension weights will tend to move downward the overall position of Canada, whereas Denmark is more likely to move up in the Index rankings due to an adjustment in the dimension weights.

The overall profiles of the position sliders demonstrates that the top and bottom third of the Index is relatively stable, while countries that occupy the middle third of the Index exhibit the potential to make large movements in Index ranking with only a slight change to the underlying weights. Interestingly, the leading two countries

Figure 4

2011 Energy Sustainability Index ranking

Source: Multiple (IEA, EIA, World Bank, WEF etc. 2009-2010)

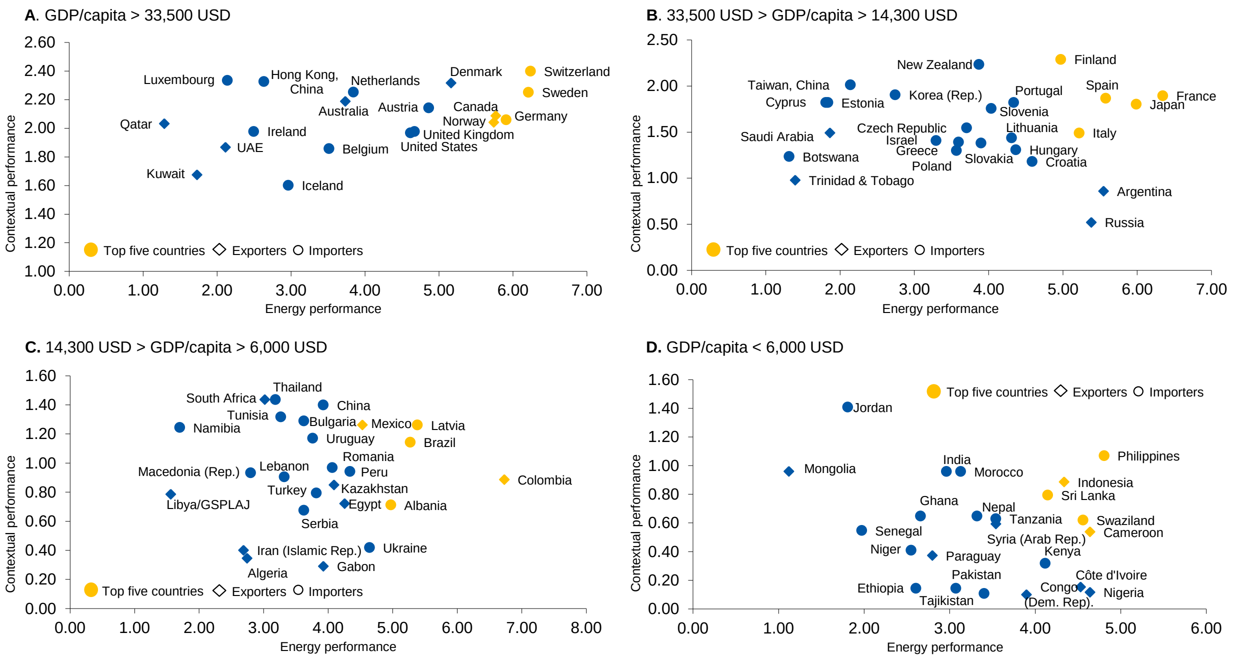
Country position slider

Rank	Country	Economic group	Export / Import	2010 rank
1	Switzerland	A	I	1
2	Sweden	A	I	2
3	France	B	I	3
4	Germany	A	I	5
5	Canada	A	E	6
6	Japan	B	I	7
7	Norway	A	E	4
8	Colombia	C	E	11
9	Denmark	A	E	9
10	Spain	B	I	10
11	Finland	B	I	12
12	Austria	A	I	13
13	Italy	B	I	18
14	United Kingdom	A	I	8
15	Latvia	C	I	30
16	United States	A	I	15
17	Brazil	C	I	23
18	Argentina	B	E	22
19	Portugal	B	I	16
20	New Zealand	B	I	19
21	Netherlands	A	I	14
22	Australia	A	E	21
23	Russia	B	E	25
24	Philippines	D	I	41
25	Slovenia	B	I	17
26	Croatia	B	I	70
27	Mexico	C	E	24
28	Lithuania	B	I	27
29	Albania	C	I	54
30	Hungary	B	I	29
31	Belgium	A	I	20
32	China	C	I	52
33	Slovakia	B	I	33
34	Czech Republic	B	I	26
35	Peru	C	I	49
36	Indonesia	D	E	31
37	Swaziland	D	I	44
38	Cameroon	D	E	39
39	Ukraine	C	I	48
40	Romania	C	I	40
41	Greece	B	I	32
42	Egypt	C	E	34
43	Hong Kong, China	A	I	53
44	Kazakhstan	C	E	73
45	Sri Lanka	D	I	60
46	Uruguay	C	I	47
47	Bulgaria	C	I	58
48	Poland	B	I	35
49	Nigeria	D	E	46
50	Israel	B	I	74
51	Côte d'Ivoire	D	E	62
52	Korea (Rep.)	B	I	36
53	Thailand	C	I	57
54	Turkey	C	I	27
55	Tunisia	C	I	37
56	Iceland	A	I	42
57	Ireland	A	I	38
58	Luxembourg	A	I	56
59	South Africa	C	E	45
60	Kenya	D	I	67
61	Serbia	C	I	59
62	Lebanon	C	I	72
63	Gabon	C	E	-
64	Tanzania	D	I	65
65	Taiwan, China	B	I	51
66	Syria (Arab Republic)	D	E	76
67	Morocco	D	I	78
68	Congo (Democratic Republic)	D	E	79
69	United Arab Emirates	A	E	61
70	Nepal	D	I	66
71	India	D	I	50
72	Macedonia (Republic)	C	I	64
73	Estonia	B	I	43
74	Cyprus	B	I	77
75	Tajikistan	D	I	83
76	Kuwait	A	E	63
77	Saudi Arabia	B	E	68
78	Qatar	A	E	75
79	Ghana	D	I	69
80	Jordan	D	I	84
81	Pakistan	D	I	81
82	Paraguay	D	E	86
83	Iran (Islamic Republic)	C	E	55
84	Algeria	C	E	71
85	Niger	D	I	87
86	Namibia	C	I	80
87	Ethiopia	D	I	90
88	Botswana	B	I	88
89	Senegal	D	I	89
90	Trinidad & Tobago	B	E	85
91	Libya/GSPLAJ	C	E	82
92	Mongolia	D	E	91

Figure 5

Energy Sustainability Index (economic groups)

Source: Multiple (IEA, EIA, World Bank, WEF etc. 2009-2010)



(Switzerland and Sweden) do not exhibit a position range—illustrating a high degree of confidence in their front-running positions.

Figure 5 shows the results of deeper Index analysis based on four economic groups, organised by GDP per capita.[7] The economic groups are as follows:

- Group A: GDP per capita greater than USD33,500
- Group B: GDP per capita between USD14,300 and USD33,500
- Group C: GDP per capita between USD6,000 and USD14,300
- Group D: GDP per capita lower than USD6,000

Examining countries by GDP per capita benchmark groups facilitates an in-depth analysis of the factors that influence country energy performance. In the analysis below, the four economic groups are further analysed to help identify distinctions between the countries. Overall, the analysis illustrates that energy-sustainability performance is in part a function of geography, natural resources, population and other 'natural' factors, but policies and deliberate choices by policymakers also play a critical role in meeting the occasionally competing goals of energy sustainability. Policymakers must chart a course to meet current social and economic needs, while ensuring energy security and environmental sustainability for the future.

The countries with a GDP per capita above USD33,500 (Group A) include both energy exporters and importers. The countries exhibit scores across the entire spectrum of energy performance, including energy security, social equity, and environmental impact mitigation, and their overall ranking on the Energy Sustainability Index. In short, the analysis shows that wealth, as measured by GDP, does not guarantee energy sustainability.

Due to their high per capita wealth these countries are similar in terms of contextual performance (e.g., political, social, and economic strength), despite vastly different government structures and energy-policy frameworks. In particular, the range of contextual scores (vertical axis in Figure 5) exhibited by this group is low compared to the other groups, signifying a greater degree of aggregate contextual similarity than the other groups. The broadly similar contextual performance of the economic group highlights the wide variety in social, economic, or political systems that can support sustainable energy performance.

The lowest scoring countries in the group include the resource-rich Middle East exporters with low energy diversity and energy-intense economies, and small European countries with low conventional energy resources. Some of the mid-range countries in the high GDP group have well-established programmes to promote energy sustainability. The top scoring countries in this group include both countries with rich energy resources such as Canada or Norway, which are able to exploit a diverse range of fossil-fuel and alternative energy resources, and countries that target energy sustainability through targeted policy deployment.

Countries with a GDP per capita between USD14,300 and USD33,500 (Group B) show a greater range of energy and contextual performance when compared to those in Group A. France and Japan top the group rankings in energy and contextual performance and have top-ten ranking in the overall Index. Both of these countries have leveraged nuclear technology to improve their overall energy performance. The two net exporters in the group, Argentina and Russia, exhibit lower contextual scores, but demonstrate strong energy performance with well-diversified energy assets and efficient use of natural resources. Countries in the middle of the group are tightly clustered and have a strong geographical link—illustrating the role a strong legacy of geo-political influence plays in energy sustainability performance.

Resource-poor energy importers and heavy oil-dependent exporters can both exhibit relatively low energy performance. Each group of countries faces an equal but opposite challenge: importers must balance energy security issues, while energy exporters must balance highly intensive energy use. The country indicators highlight that energy security is not only a function of existing fossil-fuel reserves, but also of how intensely a country is using energy. Oil exporters can face potential long-term energy security challenges due to intense and growing energy use and a lack of diversity in energy sources.[8]

Many of the countries with a GDP per capita between USD6,000 and USD14,300 (Group C) are resource rich and fast-growing, large economies, with the potential to be a future global energy exporter. However, these countries are also facing high growth in domestic energy demands, which is impacting their overall energy security. Furthermore, many of the countries in this group exhibit a strong trade-off in dimensions of energy performance, which puts these countries lower on the overall Index. Many geographically close countries in this group are closely ranked on the Index. This suggests a common pool of energy drivers influencing policy implementation in a broadly similar way.

Exporters in this group display the weakest contextual performance. However the developing-world exporters show that progress is often initially on the basis of trade-offs between energy-performance dimensions. Many exporters struggle to support the three dimensions of sustainability, given their rich resource endowment, energy requirements, and opportunity for export revenue.

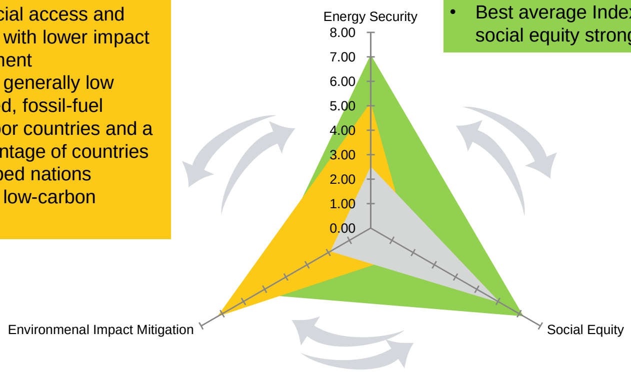
Countries with a GDP per capita below USD6,000 (Group D) are weaker in contextual performance

Figure 6

Trilemma of energy sustainability

Group 2: Limited resources and lower environmental impact
- Lowest average GDP per capita cluster
- Weak in social access and affordability with lower impact on environment
- Represents generally low industrialised, fossil-fuel resource poor countries and a small percentage of countries and developed nations focusing on low-carbon technology

Group 3: Balancing secure and affordable
- Largely developed nations with sufficient natural and economic resources to exhibit strong performance in energy security and affordable, accessible energy
- Best average Index performance, with average GDP/ capita equal to social equity strong cluster



Group 1: Highly affordable energy
- Lowest average Index performance and includes many exporters
- Generally focus on providing affordable energy often through subsidies
- Weaker performance on energy security (highly intense energy use) and environment

Group 1: Highly affordable energy	
Algeria	Mongolia
Australia	Netherlands
Belgium	Pakistan
China	Poland
Cyprus	Qatar
Estonia	Saudi Arabia
Greece	South Africa
Hong Kong, China	Taiwan, China
India	Thailand
Iran (Islamic Republic)	Trinidad & Tobago
Israel	Turkey
Jordan	United Arab Emirates
Korea (Republic)	
Kuwait	
Libya/GSPLAJ	
Macedonia (Republic)	

Group 2: Less affordable and lower environmental impact	
Albania	Morocco
Botswana	Namibia
Cameroon	Nepal
Congo (Democratic Rep.)	New Zealand
Côte d'Ivoire	Niger
Croatia	Paraguay
Denmark	Peru
Ethiopia	Portugal
Finland	Senegal
Gabon	Slovakia
Ghana	Sri Lanka
Iceland	Swaziland
Ireland	Tajikistan
Kenya	Tanzania
Latvia	Tunisia
Lebanon	Uruguay
Luxembourg	

Group 3: Balancing secure and affordable	
Argentina	Mexico
Austria	Nigeria
Brazil	Norway
Bulgaria	Philippines
Canada	Romania
Colombia	Russia
Czech Republic	Serbia
Egypt	Slovenia
France	Spain
Germany	Sweden
Hungary	Switzerland
Indonesia	Syria (Arab Republic)
Italy	Ukraine
Japan	United Kingdom
Kazakhstan	United States
Lithuania	

when compared to the other groups, but not necessarily lagging in terms of energy performance. The 'leading edge' countries in energy performance generally have poor social equity (e.g., energy affordability), while exhibiting stronger energy security and environmental impact-mitigation performance. Indonesia is unique here as it has much stronger social equity performance, but consequently demonstrates poorer energy security and environmental impact migration compared to its peers. In general, the group has strong environmental impact mitigation scores; this is not necessarily the result of policy, but rather the result of lower economic development. It highlights that sometimes countries can achieve a balance between the three elements of energy sustainability as an unfortunate result of low economic and social development.

Impossible trilemma of energy sustainability?

The energy community often asserts the challenge presented by the 'trilemma of energy sustainability': in short, when looking to achieve goals in three dimensions of energy sustainability, there will always be a trade-off in one or more of the energy dimensions.

As noted above, the Energy Sustainability Index enables an empirical exploration of the trilemma between affordable energy, secure energy supplies, and supporting environmental objectives. Figure 6 reveals the result of analysis of WEC member countries across the three energy-sustainability dimensions. A country's balance on the trilemma can be affected by a number of factors, including resource endowment, economic prosperity, standards of living, technological development, and government and institutional support.

The analysis reveals three clear groups:

- Group 1 has focused on providing affordable energy, often supported by highly subsidised energy costs. However, as a result, energy security and environmental indicators are negatively impacted. As seen in Figure 6, this group has strong social performance compared to energy security and environmental impact migration.
- Group 2 largely comprises conventionally resource poor countries, countries with limited industrialisation and heavy industry, and some countries that strongly utilise low-carbon technology. As a result, this group is lower in social equity, but achieves higher scores on environmental impact mitigation.
- Group 3 exhibits strong overall scores. However, environmental impact mitigation is the weaker dimension. This group represents the leading challenge of a developed nation—how to sustain or enhance existing energy security and social equity performance while planning and implementing a low-carbon future.

Takeaways on the energy sustainability trilemma

Perfect alignment in all three dimensions of energy sustainability is a goal no country has yet been able to successfully achieve. Trade-offs exist and countries need to make choices as they progress:

- Resource-rich and heavy fossil-fuel exporters often use their assets to bolster social equity performance, often at a cost to long-term energy security and environmental impact mitigation.
- Well diversified and developed net exporting countries tend to show increased energy security, resulting in a trade-off between social equity and environmental impact mitigation.
- Importers tend to exhibit a more balanced approach to the energy trilemma, possibly a consequence of relying less on a single conventional resource.
- Resource-poor countries and developing high-growth or production economies tend to exhibit the greatest imbalances, as resources are stretched or specific, energy-development objectives targeted.

Summary

It is clear that one of the pivotal factors of performance in energy sustainability is the effective application of existing national resources—be they energy, political, or economic assets—to ensure a diversity of energy supplies. However, countries facing similar energy challenges appear to trend together. Developing countries, seemingly weaker in contextual support and national resources, are able to obtain good energy-performance scores. This indicates that a lack of natural resources and country wealth need not necessarily be a barrier to effective energy policy that optimally leverages available country assets.

The lack of a clear relationship between wealth, and contextual and energy-performance indicators across all countries indicates that strong overall performance can be obtained by i) considering available national resources, and ii) developing a policy framework that supports energy sustainability through the value-chain to the end-user.

The trilemma of energy sustainability and resource endowment also appears to be connected for many of the developing country exporters. Several of the exporters displayed better energy performance than contextually similar net-energy importers; but the exporters would often exhibit a more pronounced trade-off amongst the energy-performance dimensions. The implication is that exporters have a natural advantage compared to net importers when it comes to energy sustainability. However, they must work considerably harder than the importers to avoid driving imbalances into the energy-sustainability trilemma, which may prove hard to reverse due to political and social opposition. For example, the use of high energy subsidies (electricity or fuel) to provide low-cost energy to citizens can enable energy inefficiency and inhibit private-sector investment in energy infrastructures. However, if commercial energy supply is not subsidised in many developing countries, the majority of the population will not be able to afford energy.

Finally, the Index also highlights the substantial role played by policy legacies and the timescales of significant change. Former Soviet Bloc[9] countries tend to exhibit one of the tightest groupings, suggesting that their common political and social legacy is still pervasive after 20 years, and still influences energy performance. The cost and impact of policy decisions and policy implementations should therefore not be underestimated.

Takeaways on the Energy Sustainability Index

- Policymaker choice is a key discriminating factor of energy performance: while countries may exhibit similar contextual positioning and resource endowments it is ultimately the choices made by policymakers that cause the energy-performance scores of otherwise similar countries scores to diverge (e.g., Korea, Republic, and Japan).

- Exporters are not necessarily good at long-term energy security, as they often tend towards a regime of over-dependence on fuel exports and low domestic-energy costs to maintain social equity (either directly or indirectly). Middle East countries in particular tend to exhibit strong social equity, due to subsidies on fuel prices, with resulting negative impacts on energy security and environmental impact mitigation (e.g., Qatar, Kuwait, and United Arab Emirates).

- National resources, wealth, and contextual performance are not the dominating factors that drive the energy-sustainability performances of individual countries. The Index suggests that countries may each need to determine their unique trade-offs for success when it comes to policy implementation to support energy sustainability.

- Energy security can change quickly in the short-term through minor policy adjustments, but long-term energy security can be eroded by an over-reliance on energy commodities, a lack of energy-asset diversification, and a lack of energy autonomy. In contrast, social equity and environmental impact mitigation metrics respond more slowly to policy signals or energy-regime developments.

- Countries can be grouped due to a common energy legacy, sharing of natural resources, or similar geographical drivers. However, such drivers can often lead to unified ‘performance inertia’, leaving countries with the challenging task of breaking the status quo through a wholesale revaluation of energy objectives and innovative policy implementation (e.g., Central and Eastern European countries).

2. Land mobility challenges

'It is imperative to make available a modern and efficient public transport system either intracity or between cities before even thinking of mandatory price rises on any type of fuel. The only effect of such policy is the increase in economic hardship for the majority of population with no reasonable effect on the consumption.'
2011 WEC Survey, Energy-Industry Executive

The mobility and transport of goods and people is critical for economic development and social cohesion. At the same time, transport is currently heavily dependent upon oil reserves, is the fastest-growing source of global carbon emissions, and is responsible for a range of other social and environmental challenges including local air pollution, noise, road congestion and accidents.

Passenger transportation represents the largest proportion of world transport fuel consumption and absorbs over 60% of the world's total oil production.[10] By 2035, the transportation sector is expected to account for close to 90% of world liquids fuel consumption, driven by continued economic growth and associated transportation needs, and by the projected demand for personal automobiles, especially in non-OECD countries (e.g., China, India, South America, Russia, and the Middle East).

Currently 50% of the world's population live in urban areas and urban populations are expected to increase by over one billion by 2030 with some of the fastest growth in urbanisation expected in Asia and Africa.[11] By 2030, 60% of the world's population is projected to live in urban areas. Urban passenger transportation is therefore a critical focus area for policymakers—especially as urbanisation has, to date, increased in accordance with the growth in private vehicles.

There is considerable scope to mitigate the negative impacts of transportation through land-use planning to reduce demand growth, shifts towards public transportation, improving vehicle fuel-efficiency, and moving towards biofuels (liquid and gaseous) and/or hybrid-electric cars. This chapter examines a number of policies that are focused on the mitigation of the impact of transportation including; the implementation of bus rapid transit systems in Brazil and Korea (Republic), congestion charges in Sweden, zero-emission policies in the USA, and the promotion of ethanol in Brazil. Together, they represent policies that are designed to:

A. Influence choices on whether and how to travel

B. Influence choices on vehicle technology and fuels

The challenge in shifting transport patterns

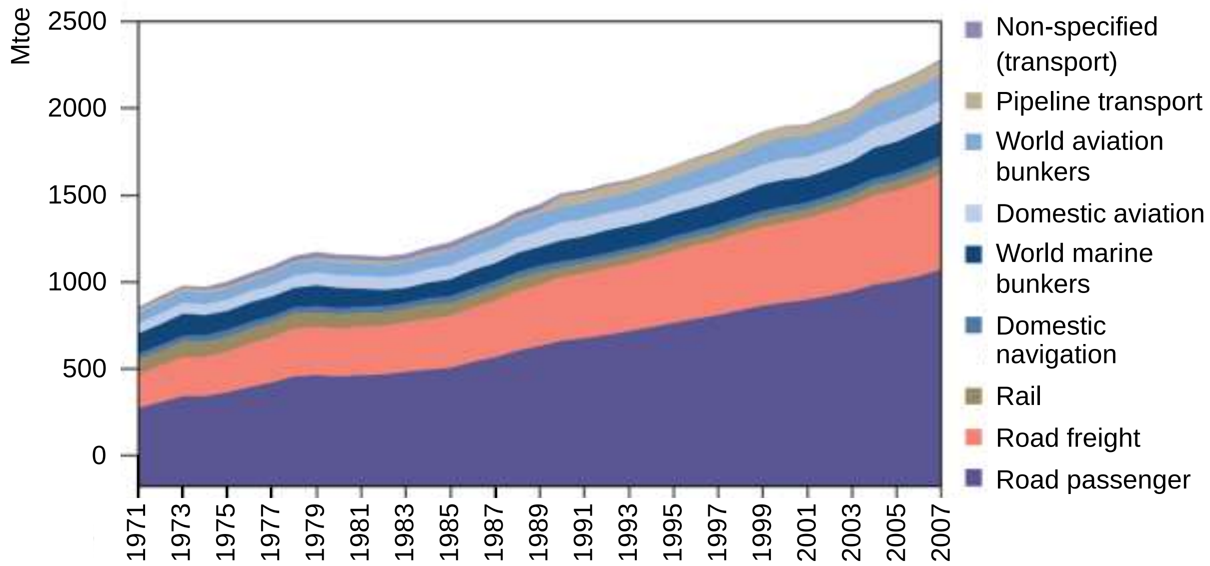
Given the trends in world population, increasing affluence, and global car ownership, there is a compelling need for a technological shift towards lower or zero-emission vehicles and for the development of alternative solutions for sustainable transport. However, encouraging sustainable transport presents an especially difficult policy challenge. Countries face many challenges including how to support new vehicle technology, renew existing vehicle fleets and improve existing infrastructure; how to lower costs in the context of meeting social and economic development; and how to reduce existing dependencies and enable free access to goods and people.

Transportation systems co-evolve with social and economic systems, land-use patterns, culture and lifestyles, and individual behaviour. For example,

Figure 7

World transport final energy use by mode

Source: IEA, Energy Technology Perspectives, 2010



increases in car ownership and car use trigger numerous, overlapping, feedback loops that make it progressively more difficult to live without a car. Each individual choice to travel by car instead of public transport tends to make the latter less attractive to those still using it, thereby encouraging more people to move away.[12] The converse can also come into play, where increasing use of public transport decreases the attraction of private transport.

'Transportation planning and policies should encourage mass transportation through clean energy.'

WEC Survey 2011, Energy-Industry Executive

The reduction of fuel use and carbon emissions from road transport requires multiple and coordinated policies that influence individual decisions on where to live and work, whether to own a car, what type of car to purchase and whether and how to travel, as well as associated decisions by land-use planners, vehicle manufacturers and other types of public and private organisations. The involvement of an exceptionally broad range of actors at regional and national levels makes the coordination of different policies very challenging.

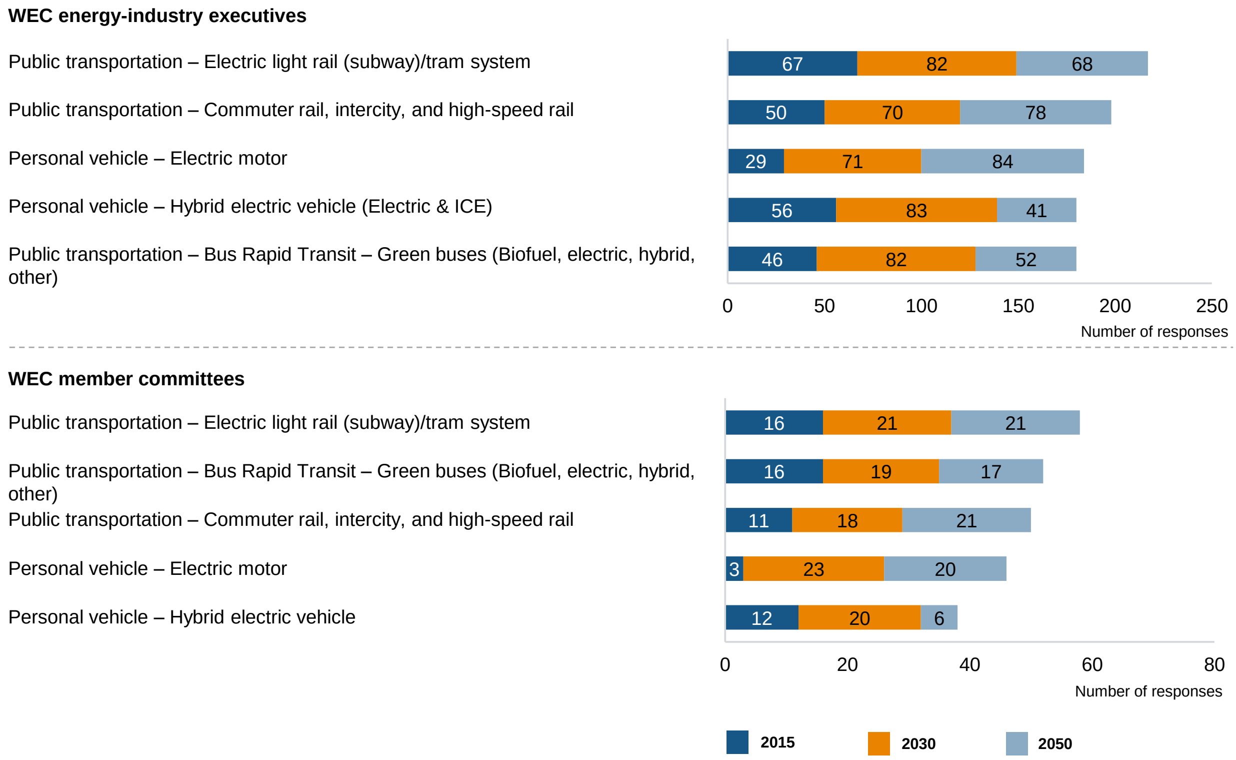
An additional challenge is the significant scale and longevity of transport infrastructure. Simply put, transport infrastructure is expensive and it is hard to introduce changes once local economies, communities, and personal behaviours are structured around existing infrastructures and patterns.

The survey results in Figure 8 reveal the opinions of energy-industry executives and WEC member committees on the top five components of future urban transportation through to 2050. The two groups agree on the top land transportation components, although not necessarily in the same order. Both groups agree that future urban mobility should be focused on mass transportation systems to support an ever-increasing urban population, with ancillary support provided by electric or hybrid technologies for personal mobility.

Survey respondents believe that internal combustion engines (ICEs) will provide the main mode of urban transportation until at least 2015, but decline thereafter, with a transition to full electric-power by 2050. Hybrid vehicles are expected to play a major role in personal travel up to 2030 and diminish thereafter, suggesting that it is perceived to be a transition technology. This survey data suggests that the implementation of technology for full electric-powered mobility, along with the corresponding infrastructure, will take some time to reach a standard acceptable to the millions of urbanised travellers. Up to 2030, Bus

Figure 8

Prioritised components of future urban mobility, as identified by energy-industry executives and WEC member committees



Rapid Transport (BRT) systems and commuter rail are expected to become increasingly important components of mass transportation. For the immediate future, the question for industry, governments, and local authorities is how to plan and implement the required changes—be they financial, infrastructural, technological, or user behaviour—to support the shift away from internal combustion engines. A particular challenge is to make public transport more attractive than personal automobiles.

Electric mobility—how to pay for the infrastructure?

Electric-powered land transport is expected to increase as it offers the most advantageous way to blend energy inputs to power the mobility levels desired by modern societies. The IEA estimates that global government targets for electric vehicles add up to over one million vehicle sales by 2015, and seven million by 2020.[13] The adoption rate of electric vehicles will likely be impacted by the challenges of large scale development of electrical infrastructure to charge vehicles, the user convenience of electric vehicles, cost and material barriers, and changing consumer perceptions.

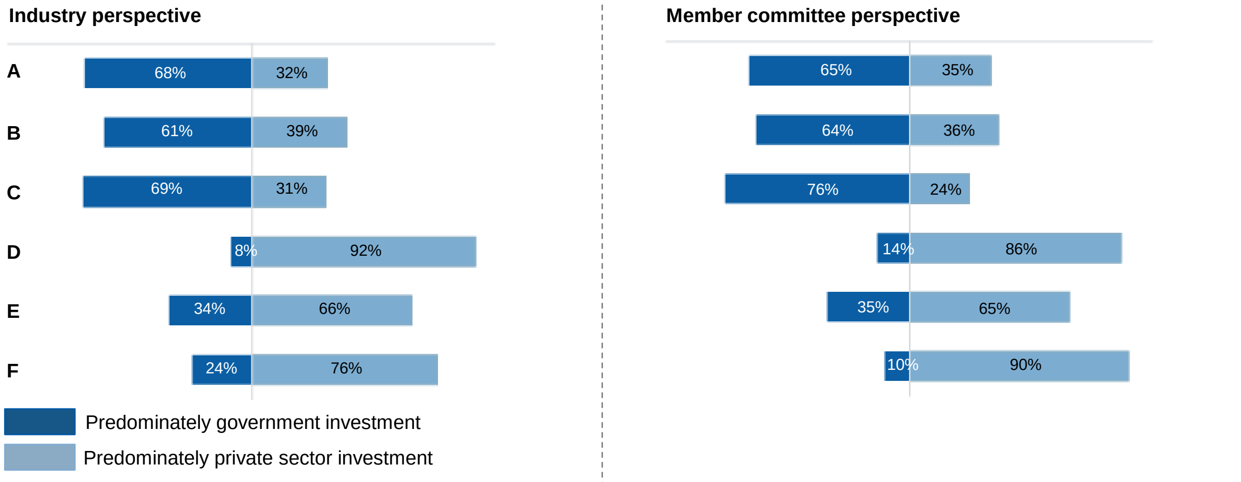
Electric vehicles cannot use existing fuelling infrastructure and it is not yet clear who and how to pay for the substantial amount of investment needed to build a recharging infrastructure. Electric charging stations are currently viewed as a risky investment because of uncertainty in the electric vehicle market, high capital costs, and the long payback periods that occur because of the low price of electricity in many countries.

As indicated in Figure 9, the survey results reveal that energy-industry executives and WEC member committees agree on who should pay for the necessary components of an electric mobility infrastructure. For example, governments should predominately pay for the necessary upgrades to infrastructure to support an e-mobility implementation, while the private sector should predominately pay for infrastructure nodes that connect with the end-user.

On-street charge points will be necessary for large-scale adoption; in the absence of other

Figure 9

Public versus private investment for key components of electric mobility infrastructure according to energy-industry executives and WEC member committees



Label	Component Name	Label	Component Name
A	Updates to the grid system to support e-mobility	D	Regular electric mobility charging stations and battery swap stations (any vehicles; home/work; ~8 hour charging)
B	E-mobility infrastructure upgrades in cities	E	Linking charging infrastructure (private or public) to network grid system (including network management, authentication, billing)
C	E-mobility infrastructure upgrades to support regional and inter-city mobility	F	Fast charging station (to overcome range concern; ~2 hour charging)

revenue sources, at today's electricity prices, public charging points are highly unlikely to be profitable. A distinction should be made between regular, fast, and super-fast public charging points. Super-fast public charging points (with around 30-minute charge times) could operate similarly to current fuel stations, and would hence be able to gain revenue from concession stores. However, these points alone will not be sufficient, given the shift in consumer behaviour required to adapt from near-instant refuelling at a petrol station to 30-minute charging of an electric vehicle.

Electric mobility will require new business models, and, potentially, government support to finance public, on-street charging points.[14] Many national and local governments are already providing strong support in this regard. For example, in May 2011, London (UK) launched Source London, the UK's first city-wide electric vehicle charging point network and membership scheme. The scheme aims to create, by 2013, 1,300 publicly accessible charging points across the city, located on residential streets and in public car parks at shopping and leisure centres. The charging points will be paid for through a mix of public and private money.[15] This city-level scheme is reinforced by the UK government's Plug-In Car Grant. Under the scheme, the motorists purchasing a qualifying ultra-low emission car can receive a grant of 25% towards the cost of the vehicle, up to a maximum of £5,000.

Other cities are also investing in electric vehicle infrastructure. For example, in the USA, San Francisco is mandating that all new buildings are wired for electric cars, and is offering free electric charging points at selected locations across the city.[16]

Policy review

Driven by a need to support increasingly urbanised populations, many governments are looking to reduce road transport fuel use, reduce carbon emissions and pollution, and traveller congestion.

The review of transport and mobility policies reflects the diversity of policy that can be applied and what can be achieved through careful design and implementation. However, as highlighted below, all the policies examined in this chapter were implemented as a component in a suite of

Figure 10
Overview of two Bus Rapid Transit systems

Goal	Mechanism	Why it works	Key challenges	Evolution of mechanism
Curitiba (Brazil) Bus Rapid Transit (BRT) system				
• Reduce congestion and noise • Create a 'liveable' and green city in a fast growing developing country[1] • Foster social equity • Manage urban sprawl by evenly distributing city development	• Bus Rapid Transit (BRT) – preferential bus route that mimics an underground transit system, which reduces trip time by using fewer, specially designed stops	• Synergy of supporting policy measures • Strong institutional will and resources for strategic land-use planning • Political stability and commitment to long-term plans • Close consultation between authorities • Strong public support	• Requires public subsidies • Executing an efficient consultation process between affected entities • Developing public support for space re-planning and changes to road use • Designing a user friendly system that makes it attractive and easy to switch transportation modes • Optimise BRT planning against existing road and bus routes • Managing zoning and other land regulatory changes to prevent increasing social disparities and property speculation	• Highly flexible concept with a set of principles and a toolbox of measures that cities can adapt to needs • New funding mechanisms, e.g. BRT system in Bogota, Columbia is one of two public transport systems registered for CDM with UNFCCC • Better understanding of physical planning challenges, e.g. impact of BRT on road use, road accidents or congestion • Application of technology for user convenience
Seoul (Korea, Republic) Bus Rapid Transit (BRT) system				
• Reform existing costly, inconvenient, slow and poorly integrated public transport system • Reduce transport emissions, pollutants, and congestion • Cost-effective alternative to an expanded metro system • Increase traffic speed	• Bus Rapid Transit (BRT) – preferential bus route that mimics an underground transit system, which reduces trip time by using fewer, specially designed stops	• Synergy of policy support measures • Focused on user convenience • Strong political and institutional support • Close consultation with stakeholders and users • Improved governance under an urban consultative body • Changed incentives for bus operators		

1. Smith, H. and Raemaekers, J. (1998) "Land use pattern and transport in Curitiba." *Land Use Policy*, Vol. 15, No. 3, pp. 233-251.

complementary initiatives, rather than as a single measure. Given the complexity involved in transportation patterns, a single measure is rarely sufficient to effect measureable change.

Influencing choices on whether and how to travel

Enhanced mass transit and public transportation (supply side) is a key focus of efforts to reduce tailpipe emissions and fossil-fuel use by reducing the use of private vehicles. Mass transit options such as subways, tramways, and electric railways can be costly compared to bus-based systems that use exiting roadways.[17] More than 150 cities around the world have implemented bus rapid transit systems (BRT): these are preferential bus routes that mimic an underground transit system.[18] BRTs can use a wide variety of rights-of-way, including mixed traffic, dedicated lanes on surface streets, and busways completely separated from traffic. Two such systems are illustrated in Figure 10.

Both the Curitiba (Brazil) and Seoul (Korea, Rep.) Bus Rapid Transit systems were embedded within a wide range of integrated and overlapping policies all geared to supporting the overall effectiveness of public transport and/or pedestrian access and decreasing the attractiveness of personal automobile use. Measures included greater coordination of public transport services, better passenger information systems, regulation of private bus operators, investment in pedestrian and cycling facilities, environmental education, parking charges, and (in Seoul) road pricing. The suite of policy measures used to support the implementation of BRT systems leads to one clear success factor—convenience for the end-user. Many small innovations can help support that objective, for example, a contactless 'smartcard' bus-pass, as adopted by the Seoul (Korea, Rep.) BRT, or increased connectivity of different modes of public transportation. Governments can also undertake education and advertising campaigns to make bus use more attractive.

'A shift of private mobility from fossil to electric does not dissolve traffic jams. Only public transport can help.'

WEC Survey 2011, Energy-Industry Executive

There can be negative unintended consequences when implementing a BRT. Changes to public transport must be considered for the impacts on

Figure 11
Overview of the Stockholm congestion charge policy

Stockholm (Sweden) congestion charges				
Goal	**Mechanism**	**Why it works**	**Key challenges**	**Evolution of mechanism**
• Reduce vehicle congestion and increase overall travel speed[1] • Improve air quality • Lower fuel consumption • Improve quality of public transport service	• Road congestion pricing • Single charging cordon around inner city on weekdays between 6:30 and 18:30 [1] • Charges varied according to time of the day and is the same when entering and leaving toll area and at all charging points[1] • Charge capped at €6[1]	• Supported by integrated package of measures including increase in public transport services and "park and ride" services • Priority assigned to understanding and simplicity compared to potential maximum efficiency • Introduced a trial period to refine programme design • Focused on building public and political acceptance with a referendum • Applied information campaign supported by extensive and scientific evaluation and transparency • Ensured local benefits as revenue benefited city	• Potential weakening of policy due to need for consensus • Sustaining reduced traffic volumes • Unique "consensus culture" and high environmental awareness of Sweden may not be replicable in other countries	• Variable pricing, e.g. Singapore's congestion pricing system • Milan and London considering excepting alternative fuel vehicles from congestion charges • Some cities have adopted the charge to primarily provide revenue as compared to goals of reducing emissions, e.g. Gothenburg[2]

1. Eliasson, J. (2008) "Lessons from the Stockholm congestion charging trial." *Transport Policy* 15(): 395-404.
2. Börjesson, M., Eliasson, J., Beser Hugosson, M., Brundell-Freij, K. (2010) "The Stockholm congestion charges – four years on. Effects, acceptability and lessons learnt." Paper presented at the 12th WCTR, July 11-15, 2010 – Lisbon, Portugal.

the entire transit system. For example, the introduction of BRT infrastructure or dedicated lanes in established areas often leads to increases in non-BRT travel time, as well as pollution and bottlenecks in non-corridor areas. Planners must also consider how the BRT will affect road-usage rules, for example, ensuring that there are no slow-moving vehicles in the BRT corridor will support efficiency. These potential negative impacts highlight the importance of robust planning and public consultation, especially when introducing a BRT system into heavily populated areas. There must be popular support around the re-purposing of existing roadways for mass transportation systems, since vested interests might oppose any proposed policies. Strong planning will also help to reduce the incidence of road traffic accidents occurring due to changes in road usage.

Along with enhancing public transport and its appeal, policymakers are implementing disincentives for private vehicle use in many cities. These efforts need to be coordinated carefully. Without coordination, cities may face only partial and unstable adoption of new transportation options at a higher cost. Disincentives for car use may include increased use of pedestrian lanes, parking fees, low-emission zones[19] and congestion charges. Cities around the world, including London, Singapore, and Milan have implemented congestion charges—a system of surcharging road users in periods of peak demand to reduce traffic congestion. Congestion charging has been advocated by transport economists for decades but rarely implemented, due to either actual or expected public and political opposition, and concerns about its impact on social equity and mobility. As such, this policy is a specific example of the trade-offs policymakers must balance out in the energy-sustainability trilemma discussed in Chapter 1.

Figure 11 summarises the Stockholm congestion charge system. This is a rare example of success in terms of its lasting effect on reduced traffic volumes. It also demonstrates that while a pilot test phase for a controversial policy may be expensive and politically risky, it can support a favourable outcome in a referendum. The Stockholm authorities gained public acceptance for the scheme for a number of reasons: careful and pragmatic design; a robust information campaign targeted at motorists; extensive and scientific evaluation, including almost real-time information provided to the citizens on traffic system performance[20]; clear and measurable objectives; and the increase of public transport services to absorb the increasing customer demand.[21] Overall, policymakers were able to develop strong support for the measure as an overall increase in the quality of life for the citizens and not just on the

Figure 12
Overview of the California Zero Emission Vehicle mandate

California (USA) Zero Emission Vehicle (ZEV)				
Goal	**Mechanism**	**Why it works**	**Key challenges**	**Evolution of mechanism**
• Reduce serious and persistent air pollution problems • Overcome obstacles to radical innovations and the deployment of advanced-technology vehicles and infrastructure • Pursue federal air quality standards – especially for ambient ozone levels – against a backdrop of rapid growth of population and vehicle stock[1]	• Technology-specific performance-based regulation • Mandate on major car companies to make available for sale vehicles with zero tailpipe pollutant emissions • Adopted in 1990 as part of the Low Emission Vehicle programme	• Helped focus car manufacturers' efforts on production of cleaner cars • Regulators adapted mandates due to successive, unanticipated changes in conventional and hybrid vehicle technologies • Changes in conventional and hybrid vehicle technologies resulted in emission reductions reaching initial targets[2]	• "Technology forcing" mandates can be adversarial • Mandates place high demands on regulators' skills to anticipate future technology developments • Overestimated potential of one technology (electric vehicles) and underestimated potential for improvements in conventional vehicle technology • Need to adapt policies to reflect unexpected technology developments	• Credit for new types of clean conventional vehicles as well as for vehicles employing advanced technology but with above-zero emissions, including PZEVs (Partial Zero Emission Vehicles) and AT PZEVs (Advanced Technology PZEVs)

1. CARB (2009) "Summary of Staff's Preliminary Assessment of the Need for Revisions to the Zero Emission Vehicle Regulation." *State of California Air Resources Board.* White Paper.
2. Bedsworth, L.W. and Taylor, M.R. (2007) "Learning from California's Zero-Emission Vehicle Program." *CEP - California Economic Policy* 3(4): 1-19.

basis of environmental sustainability. It should also be noted that the Stockholm policymakers sought primarily to secure public support for an effective congestion charging system. They did not strive to implement an optimised congestion charge system nor did they extend to debates on fundamental issues of mobility.[22] A sceptic might therefore view the Stockholm congestion charge as a mere substitute for more fundamental changes in transport policy.

Congestion charges have demonstrated lasting reductions of traffic congestion in cities. Indeed, one recent study suggests that congestion pricing is the most effective tool to curb traffic congestion in cities—above improved or road capacity.[23] However, when considering adaptations to the mechanism, such as exempting alternative-fuel vehicles from congestions charges, policymakers must consider the potential impacts on goals such as reduced traffic congestion. Going forward, policymakers will need to ensure that incentives for the adoption of electric-powered private vehicles do not over-ride original de-congestion efforts, or, indeed, that de-congestion efforts do not impede the future of electric-powered urban mobility.

'There is no future in biofuel from food-related sources; however, biofuel from non-food related sources may have a bright future.'

WEC Survey 2011, Energy-Industry Executive

Influencing choices of vehicle technology and fuels

Policymakers have also focused on initiatives to change the vehicle technology and/or reliance on fossil fuels. These efforts can be successful but can also create unintended consequences, as highlighted by the two programmes illustrated below: California's zero emission vehicle programme and Brazil's ethanol programme.

Choices of vehicle technology

Figure 12 shows the California Zero Emission Vehicle (ZEV) mandate. This highlights the challenges of 'technology-forcing' regulations, with some commentators claiming the initial policy failed. This assertion was based on an overestimation of the potential of electric vehicles and an underestimation of the potential for improvements in conventional vehicle technology.[24] As a result of the miscalculations, the programme went through three major modifications in the late 1990s and early 2000s, providing credit for new types of clean conventional vehicles, as well as for vehicles employing advanced technology but with above-zero emissions.

Ultimately, the adapted mandate achieved nearly the same level of reductions of regulated air pollutant emissions as would have been achieved through the original target of 10% ZEVs in the

Figure 13
Overview of ethanol programme in Brazil

Brazil's ethanol programme				
Goal	**Mechanism**	**Why it works**	**Key challenges**	**Evolution of mechanism**
• Reduce oil import dependence • Foster economic and technological development • Reduce air pollution and greenhouse gas mitigation • Reduce regional disparities by expanding agricultural frontier and creating rural jobs	• Proálcool – National alcohol programme to promote ethanol as an alternative to fossil fuels • Initially introduced subsidies (e.g., credit support) to sugarcane and ethanol producers, protection of domestic production against competition, price controls at the pump, and incentives for ethanol R&D[1] • Currently ethanol receives no direct subsidies, but receives favourable tax treatment and support via blending mandates, and other measures	• Exceptionally favourable natural conditions for sugarcane cultivation • Long-term political support and development of needed institutional capabilities • Integrated system of ethanol production and consumption, including sufficient institutional stability to make ethanol economically viable • Public-private collaboration in creating a solid 'innovation system' around ethanol-related R&D	• Maintaining an effective balance between environmental sustainability goals and national, regional, and local objectives – be they social, economic, or environmental • Managing indirect land use impacts due to sugarcane expansion and field rotation • Ensure sugarcane cultivation does not lead to a concentration of land ownership or slow diversification of agricultural or other economic activity	• Electricity production from programme to cover consumption of ethanol producers with opportunity to sell excess electricity back to the grid • Implementation of mechanical harvesting of sugarcane to avoid injuries and pollution associated with manual harvesting (minor exceptions based on environment)

1. Puppim de Oliveira, J. A. (2002) "The policymaking process for creating competitive assets for the use of biomass energy: the Brazilian alcohol programme." *Renewable and Sustainable Energy Reviews* 6, 129-140.

fleet.[25] In addition, the mandate produced a range of spin-off effects (e.g., increased patenting activity), which could hardly have been achieved through the use of non-technology-specific, performance-based regulation alone. Innovation was also boosted in other areas of car technology and low-speed electric vehicles, such as bikes or scooters and 'city' electric vehicles.

Overall, the experience highlights that 'technology-forcing' mandates place high demands on regulators' capacities and skills to anticipate future technology developments. At the same time, the policy illustrates positive unintended consequences, as a result of the flexibility and skill with which the mandate was successfully modified in response to new technology and information.

Taking the whole life-cycle view

Policymakers need to consider unintended consequences and the whole life-cycle of electric-mobility. There are many questions regarding the trade-offs and overall benefits in terms of reducing carbon dioxide and greenhouse gas emissions. The calculations and cost assessments regarding potentially reduced tailpipe emissions and fossil-fuel reliance associated with electric mobility become challenging. Cost-wise, price per percentage carbon dioxide reduction may be relatively high, and more cost-effective methods to reduce carbon emissions may be available. For example, increasing efficiency by reducing the vehicle weight of internal combustion engines. In addition, if electricity is generated with low-efficiency, coal-fuelled power plants, a portion of the greenhouse gas emissions may be transferred from the car tailpipe to the electricity grid.

There are other difficult questions. As vehicles become increasingly electrified, their emissions may begin to be regulated by other policies, such as those focusing on the electrical power sector and driver end-user efficiency. In this case, new methods and standards for evaluating and regulating the energy efficiency of vehicles will be necessary. Furthermore, policymakers will need to consider the impacts on tax revenue, since most governments rely on fuel taxes to support the road infrastructure. As electric vehicles reach high market share, this tax revenue may need to be replaced.

Reducing reliance on fossil fuels

Brazil launched its national alcohol programme, Proálcool, in 1975 in response to the first oil crisis, rising oil prices, and the rapid collapse of sugar prices in the world market, which threatened the politically powerful sugar and ethanol producers. The programme was highly successful in fostering ethanol production and consumption and helped Brazil reduce its dependence on oil imports—

saving an estimated USD52.1 billion (in USD of January 2003) in foreign currency between 1975 and 2002.[26] The use of ethanol has also been promoted since the late 1980s as a means to reduce air pollution, and greenhouse gas mitigation. Figure 13 shows an overview of the Brazilian ethanol programme.

The success of the Brazilian ethanol programme highlights the impact of long-term, concerted government efforts and public-private collaboration in creating a solid ‘innovation system’ around ethanol-related R&D. Gathering similar, long-term political support and building the needed institutional capabilities are major challenges, especially for developing countries that are seeking to become biofuel providers.

The implementation of the ethanol programme has resulted in several unintended consequences over the years. In particular, there has been significant waste product from the process, which is treated to return water to the plantations. The treatment process also produces methane, which is now being used as fuel for the ethanol production process. Other positive impacts have been the sale of exhausted yeast, almost pure protein, derived from the sugarcane-juice fermentation. This can be used for cattle feed and the production of sugarcane bricks used in restaurants and other establishments as a substitute for wood fuel. In addition, the likely development of mechanised harvesting will provide environmental benefits (less plantation burning) and will cut down on manual labour injuries, such as exhaustion and cuts from the sugarcane. But this will come at the expense of jobs, leading to local social impact.

Overall, the Brazilian ethanol programme illustrates some of the difficult trade-offs between national energy security, environmental sustainability goals, and social and economic objectives.

Summary

The future structure of urban passenger mobility remains uncertain. Many factors remain unknown, including the rate of adoption of electric vehicles, the ability to finance the necessary infrastructure changes, and the success of policies to change individual preferences for private vehicles.

Despite this uncertainty, government can positively influence oil consumption in road transportation by implementing policies that set standards, drive the supply of desired technology, and give incentives for optimal consumer behaviours.[27] The selected instruments demonstrate that it is possible to design transport and mobility policies that can make a real contribution to environmental and social objectives. In addition, many of these policies have the potential to be successfully implemented in national and regional contexts in both the developed and developing world.

Checklist for policy design and implementation: mobility

Policies geared to addressing urban passenger mobility must support a complex range of objectives and the appropriate solutions may vary with local conditions. Nevertheless, the policy review reveals a checklist of factors that policymakers should consider:

- Deploy an integrated package of mutually supportive policy measures that focus on user convenience. These policies may include greater coordination of public transport services, better passenger information systems, effective incentives for private bus operators, investment in pedestrian and cycling facilities, environmental education, parking charges, and road pricing. The deployment of alternative transportation options and an integrated programme of incentives are essential for overcoming public opposition to negatively perceived policies, such as charges for road use and parking.

- Consider long-term economic and social needs. Transport and mobility policies must look at the long term impacts on society and the economy, and support any desired changes. While public transport may offer only limited potential for replacing car transport in the short-term, long-term impacts may be substantially greater. For example, the neglect of public transport in a region can encourage the development of car-dependent infrastructures and lifestyles that can be very difficult to reverse.

- Use consultation and collaborative approaches to build public support. Public support for changes in urban mobility is critical if individual behaviour is to change. Changes to transit systems will affect all players in the system, public and private vehicle users and public and private sector providers: consultation and stakeholder engagement is critical to build support.

- Consider unintended consequences of changing transportation infrastructure and systems. For example, the introduction of Bus Rapid Transit systems can have an initially positive effect on social equity, but can raise land values along the transit corridors, forcing low-income groups to relocate to remote areas with inadequate transport infrastructure.

- Be ready to adjust policy mechanisms to offset rebound effects. Successful transport policy requires flexibility and frequent adjustments to offset ‘rebound’ effects. For example, reducing the cost of car travel through efficiency measures, without other supporting policies, can result in encouraging more driving; high-speed rail investment might inadvertently promote increased travel and more long-distance commuting.[28]

3. Encouraging energy efficiency

'Guaranteed levels of return on investment encourage the private sector to invest in new technological breakthroughs in energy efficiency … an equal degree of commitment from governments and the private sector maximises the chances of a successful implementation.'

2011 WEC Survey, Energy-Industry Executive

Any consideration of how to meet the world's growing demand for energy must include a focus on energy efficiency. Energy efficiency has long been a key target for energy and climate policies throughout the world. This is with good reason: an extensive body of evidence indicates that it is theoretically possible to improve the energy efficiency of most sectors of the global economy by up to a factor of ten.[29] Further, a significant proportion of this potential would appear to be cost-effective at current energy prices.[30]

Improvements in the energy efficiency of the global economy have, to date, made the greatest contribution to restricting the growth in global carbon emissions and reducing the growth in energy consumption.[31] This, in turn, leads to less urgent need to invest in energy supply, improves energy security, increases economic productivity per unit energy, and improves social equity by providing enhanced energy services at less cost. Overall, encouraging energy efficiency is often viewed as the single biggest and most cost-effective option for achieving progress towards a lower-carbon economy.

Nonetheless, policymakers and the energy industry alike, in various regions throughout the world, face one of the most difficult challenges of energy efficiency: first, how to promote energy efficiency when the energy is cheap and, second, how not to price energy to the detriment of development and access. This is a particular problem for the electricity industry.

Overcoming market limitations

Despite compelling arguments, energy efficiency is still not yet realising its full potential.[32] This is due to consumer behaviour, actual technology developments falling short of projections, and challenges in directing financing to energy-efficiency opportunities. Factors hindering the progress of energy efficiency include: the continued widespread use of common appliances with much lower efficiency than leading technologies (for example, in developing countries there is significant trade in older or second-hand electric appliances and cars, due to the higher costs of newer more efficient technologies); the inertia of existing car technologies; and the 'rebound effect' (see text box). There are also limitations and market failures in energy service markets that further inhibit the progress of energy efficiency. These can be categorised as follows:

- Imperfect information: Information on energy consumption is frequently missing or ambiguous, making it difficult to compare product performance and to evaluate potential energy savings. As a result, cost-effective opportunities to improve energy efficiency are frequently overlooked.
- Split or limited incentives: Any energy-efficiency opportunities are likely to be missed if people cannot appropriate the benefits of the investment. For example, the landlord of a building may be unwilling to retrofit an apartment to reduce energy consumption,

since the resulting savings would be realised by the tenant.

- Limitations on decision-making: Owing to constraints on time, attention, and the ability to process information, individuals do not make decisions in the manner assumed in economic models.

Put simply, with regards to energy-efficiency initiatives, suppliers and consumers are faced with challenging questions on effectiveness of new technologies. These include: who pays, who benefits, when benefits will occur, how benefits are measured and received, and the overall challenge of decision-making in the face of complex and sometimes unclear information. Effective policies can help overcome human and market limitations.

Financing energy efficiency

The UK government's 2010 'Green Deal' Proposal aims to tackle challenges of split or limited incentives that can inhibit the implementation of energy-efficiency measures. The goal is to establish a framework to enable private firms to offer consumers energy-efficiency improvements to their homes, community spaces, and businesses at no upfront cost, and recoup payments through a charge in instalments on the energy bill. The Green Deal plan will remain attached to the property. Thus as residential or business properties exchange hands, the Green Deal obligations—and benefits—are passed on to future occupiers. In this way, the energy benefits are tied to those who receive them directly, and consumers can leverage the lower capital costs of energy suppliers.

Rebound effects from energy-efficiency improvements

Cost-effective energy-efficiency improvements will not reduce energy consumption by as much as simple engineering estimates suggest, owing to a variety of so-called rebound effects which reduce the energy savings achieved.[33]

Since energy-efficiency improvements reduce the marginal cost of energy services, the consumption of those services may be expected to increase, thereby offsetting some of the predicted reduction in energy consumption. Even where there is no direct rebound effect for a particular energy service, consumers may re-direct consumption savings to purchasing other energy-consuming goods and services. For example, a home-owner who saves money on energy bills may use some or all of those savings to purchase additional goods and items for the home—which have an energy cost in production—thereby partially mitigating the initial energy savings.

Rebound effects also apply to the production side of the economy. For example, producers may use the cost-savings from energy-efficiency improvements to increase output, thereby increasing consumption of energy inputs as well as capital, labour, and materials, which also require energy to provide. If energy-efficiency improvements are sector-wide they may lead to lower product prices and increased consumption of the relevant products, further increasing energy consumption. All such improvements will increase the overall productivity of the economy, thereby encouraging economic growth, and leading to increased consumption of goods, services, and energy.

Rebound effects are extremely difficult to measure, but they may be expected to increase in magnitude over time as markets, technology, and behaviour adjusts. Studies on household energy services in the OECD suggest that direct rebound effects typically offset less than 30% of the potential energy savings, and may decline in the future as demand saturates.[34]

Rebound effects may be mitigated by progressively increasing energy prices, such as carbon/energy taxes, or imposing progressively more stringent cap and trade schemes, or through non-price policies, such as building regulations. But, more fundamentally, both analysts and policymakers need to recognise the existence and importance of such effects and the need to take them into account in policy appraisals.

'Private enterprise investment in energy efficiency programmes in our sector can have the greatest impact by making proper and careful choices of energy generating and consuming equipment.'

WEC Survey 2011, Energy-Industry Executive

WEC member committees and energy-industry perspectives: energy-efficiency programmes with the greatest impact

WEC member committees and energy-industry executives were asked to identify where private enterprise investment in energy-efficiency programmes has the greatest impact, including both industrial and residential situations.

The responses from energy-industry executives highlighted the following key areas:

- Effective building design and appropriate use of insulation and lighting, to help manage end-user consumption in commercial and residential properties
- Near real-time measurement of energy consumption, enabling all end-users to manage their own consumption on a cost-basis and encouraging increased energy-efficiency awareness
- More efficient generation of power, heat, and steam in upstream and downstream operations, and the renovation, and modernisation of aged plants to maintain affordable and accessible energy, while managing the carbon footprint of power generation and reducing waste heat; these efforts can focus on operations such as Combined Cycle Gas Turbine (CCGT), Combined Heat and Power (CHP)
- Current production and distribution mechanisms for efficiency to help to reduce energy losses, resulting in lower energy demand, and demands for new power facilities

Policy review

The number and ambition of energy-efficiency policies have grown considerably over the past two decades and the policies have been applied in both developed and developing economies. As a result, policymakers can draw upon a wide range of experience when designing and implementing policies based on 'what works' in encouraging energy efficiency in different markets and sectors—although, effectiveness will always be sensitive to particular market, political and cultural conditions.

'It's system integration that's vital to achieving the ultimate efficiency that would drive costs down dramatically.'

WEC Survey 2011, Energy-Industry Executive

Many countries have implemented a range of non-price policies to target both supply and demand, and promote energy efficiency within residential and consumer markets. Non-price based policies can include minimum energy efficiency standards (MEPS), labelling schemes, tax credits/allowances, investment subsidies, regulatory standards, and negotiated agreements. Five non-price policies are illustrated in the following pages: energy efficiency labelling schemes in the USA and Brazil; the Japanese Top Runner Programme, focused on developing efficient household and industrial products; the Chinese 1000 Enterprise program, focused on heavy manufacturing; and the UK's Energy Efficiency Commitment, focused on reducing residential-energy use.

Information programmes and labelling schemes

Energy-efficiency information labelling on appliances and electrical equipment, as a means to improve the market for energy-efficient products, has been implemented in approximately 60 countries.[35] In addition, many countries have also adopted labelling schemes for buildings: for example, Denmark's Energy Labelling Scheme for Small Buildings, Australia's energy ratings for residential homes, and Singapore's Energy Smart certification program to rate the energy performance of commercial buildings.[36] These mechanisms aim to help consumers and businesses to overcome limitations on decision-making, and to better identify and select energy-efficient products and equipment. At the same time, it is intended to encourage manufacturers to improve performance of their products and compete with each other. Two examples are illustrated in Figure 14.

The USA Energy Star programme is a voluntary labelling scheme for household products and commercial building equipment, covering more than 60 product categories. Over time, the programme is expanding to include residential homes, services, and commercial building. It is widely considered to be a success and has delivered substantial energy savings and emissions reductions.[37] It is also viewed as a driving force behind important technological innovations, such as efficient fluorescent lighting, power management systems for office equipment, and low standby energy use. It has been adopted in a number of countries: for example, the EU and the USA signed an agreement on the implementation of the Energy Star programme in the EU in December 2000, and renewed the agreement in 2006 for a second five-year period. Similar Energy Star agreements have been implemented in several other countries, including Japan, Canada and Australia.

PROCEL Seal is also a labelling scheme that evolved over time to set minimum energy-

Figure 14

Overview of USA Energy Star and the Brazilian labelling programme

Goal	Mechanism	Why it works	Key challenges	Evolution of mechanism
USA Energy Star programme for energy efficient household and commercial products				
• Reduce air pollution, green house gas emissions, and energy consumption by encouraging purchase of energy-efficient products • Provide reliable information on energy efficiency and transform market for energy-efficient products • Substantially increase market share of energy-efficient products over time	• Label awarded to products that are 10 - 25% more energy efficient than minimum federal standards • Voluntary scheme without (initially) independent, third-party verification for majority of product categories	• Focus on brand management and high consumer awareness • Developed a "brand promise" that energy star appliances will not include tradeoffs in performance or quality and are cost effective to own • Transparency in standard setting and implementation and high level of trust in regulator • Simple and easy to understand by consumers including easy-to-use assessment tools • Careful targeting to different types of energy users • Complementary with other energy-efficiency schemes at federal and state level	• Maintaining a brand of credibility and integrity when reliant upon self-certification • Ensuring supporting legislation and implementation policies • Requires governance structures for overall programme • Ensure no fraudulent claims or programme abuse by inadvertent incentives for malpractice • Relies on strong political commitment over a sustained period of time • Continuous iteration of labelling schemes to reflect technological developments	• Potential to franchise energy-efficiency brands in other jurisdictions by leveraging obtained experience and help develop international recognised norms • Application to new homes and home-improvement services • Independent certification, e.g. national or regional testing centre. This may be a constraint in many developing countries and regional centres could provide a solution • Enhance evaluation with inclusion of wider parameters in performance testing, such as climate and weather influence on energy consumption and reduction in efficiency during lifetime of electric equipment • Develop a programme for traffic and transportation, noting that electric cars require a more flexible framework than existing cars
Brazil's labelling programme (PROCEL seal) for energy efficient household and energy consuming equipment				
• Increase national production of energy-efficient equipment and household appliances • Transform market for energy-efficient products through technological development • Inform consumers on how to purchase more energy-efficient appliances	• Labelling scheme based on a five-point scale against government-set, minimum energy-performance standards (MEPS) • Best performing products awarded PROCEL seal • Products are tested by independent testing organizations	• Focused first on products that contributed most to domestic electricity consumption • Mandatory labelling for common household appliances • Creation of a domestic market for low-energy appliances		

performance standards for appliances. The programme is part of Brazil's National Electricity Conservation Programme (PROCEL) which aims to promote energy efficiency across electricity production and consumption, focussing in particular on reducing electricity consumption from electrical equipment. Before 2001, the use of energy-efficiency labels was based on voluntary agreements, but became mandatory for the majority of equipment, like home appliances, due to national energy shortages. The programme is claimed to have benefited energy security and lessened environmental impacts by both reducing domestic electricity consumption, especially in end-user products, and creating domestic markets for low-energy appliances.

Labelling and information schemes aim to mitigate the issue of missing or misleading information and tackle the challenge of imperfect information in the market place. The Brazilian and USA examples demonstrate that they can be very successful in transforming markets and consumer interest towards more energy-efficient products. Two factors are seen as critical to their success: generating consumer demand for efficient products, and consumer confidence and trust in labelling schemes.[38] The US Energy Star programme has been consciously developed and managed as a 'brand' with the goal of working with the marketplace to capitalise on the motivations of individual actors and consumers. As a result, the Energy Star label is a widely recognized product label and, given consumer attachment to the brand and the concept of energy efficiency in appliances, most large appliance stores now only want to stock Energy Star products.

In turn, trust in the labelling schemes requires institutional capabilities to develop, implement, communicate, and monitor the schemes, as well as test new products. Effective mechanisms are required to assess the implications of technological advancement in product development, the actual cost-effectiveness of energy savings, and the compliance of such programmes.[39]

Negotiated agreements

Negotiated agreements are commonly adopted as an alternative to either mandatory regulations or carbon/energy pricing. Two examples are exhibited in Figure 15 with the Japanese Top Runner programme targeted at suppliers of energy-using equipment, and the Chinese 1000 Enterprise targeted at energy-intensive manufacturing industries. These programmes aim to overcome some of the challenges presented by split incentives and limitations on decision-making.

Japan's Top Runner programme is aimed at fostering innovation and reducing energy consumption within the broader goals of energy security and climate policy. The programme is applied to 23 product categories, including household appliances and passenger and freight vehicles. These products share three main characteristics: they are in common use in Japan, consume substantial energy during operation, and have the potential to improve energy efficiency.

Research suggests that the policy has helped to mitigate the environmental impacts of energy consumption, and it is now considered one of the major pillars of Japanese climate policy.[40] However, not all energy-efficiency improvements in the product categories can be attributed to the Top Runner programme, since other factors such as shifts in energy prices, growing environmental consciousness, and producers' responses to emerging market demand will also have influenced the improvement process.

The structure and administration of the programme can be challenging. It is costly to maintain, generates large datasets, and poses the very difficult task of identifying the number one product in various categories. Furthermore, the product-target revisions take place every few years, with subsequent improvements diminishing year-on-year. Furthermore, the programme focuses on incremental improvements rather than radical innovation–and radical innovation could potentially lead to the development of products that fulfil the same service in a more effective way.

The transferability of the programme has yet to be fully demonstrated, and successful transfer is likely to require adaptation to different contextual, institutional, and cultural contexts. In July 2011, China announced that they would adopt the Top Runner programme by the time of the twelfth Five-Year Plan, and Korea (Republic) has adopted the concept of the Top Runner programme. Only the future will show whether or not the Top Runner programme can be transferred in this way.

Figure 15
Overview of Japanese Top Runner programme and Chinese 1000 Enterprise programme

Goal	Mechanism	Why it works	Key challenges	Evolution of mechanism
Japan's Top Runner programme				
• Develop 'world's best energy-efficient products' by stimulating continuous efficiency improvements in appliances, machinery, and equipment within residential, commercial, and transportation sectors in Japan • Support compliance with Kyoto Protocol • Improve energy security by reducing growth rate of energy demand	• Voluntary programme participation with compulsory standards • Companies aim to develop most efficient products, which will set a continuous rising standard for others to meet • Selected product categories have three main characteristics: commonly used in Japan, consume substantial energy during operation, and have potential for energy-efficiency improvements	• 'Compliance' based on unique interaction between government and industry and cultural norms • Focuses on supply-side and technology improvements with incentives to invest in R&D • Iterative, allowing scope and stringency to be continuously modified • Negates market or techno-economic analysis by setting standards based on current equipment • Flexible, as allows sale of less efficient equipment provided higher efficiency models are available • Complements other energy-efficiency schemes • Technology-specific standards	• Innovation and technology development is an uncertain, challenging, and context-dependent process. May not be effective approach for products whose rate of technological development is difficult to forecast • Impact on consumers and effect of increased product prices from improved energy • Primarily focused upon incremental innovation in specific product categories with little incentive for radical innovation	• Improved evaluation of overall impact of the programme • Determining how to transfer to a European context given differences between European and Japanese administrative cultures and public-private relations • Apply Top Runner programme to heat-pump water heaters and electric motors – not only for electric mobility
China's 1000 Enterprise programme				
• Improving energy-efficiency of 1000 most energy-intensive industrial enterprises in China clustered in nine industries • Target to reduce energy consumption per unit of GDP by 20% between 2005 and 2010	• Negotiated agreements between the Chinese government and large-scale enterprises in major energy-consuming industries • Companies formulate energy-efficiency goals, establish an energy-utilisation reporting system, conduct energy audits, formulate an energy conservation plan, adopt energy conservation incentives, and invest in energy-efficiency improvements	• Simple and preliminary guidelines • Financial incentives and potential of penalties to both incentivise compliance and phase-out inefficient enterprises • Hierarchical guidance from national government supported by local authorities • Education and training of industrial workforce – including educational events and availability of energy-auditing software to assist enterprises	• Uniform targets not detailed assessments of energy-savings potential of each enterprise or each industrial sector • Programme has not yet developed a systematic means for gathering or disseminating energy-efficiency information to/from the participating enterprises • Limited integration with other or complementary policies that support efficiency	• Replace negotiated agreements with mandatory standards • Second phases of programme may require higher levels of investments once initial efficiency improvements have been made • Implementation and further development of an energy-auditing standard to ensure an even benchmark

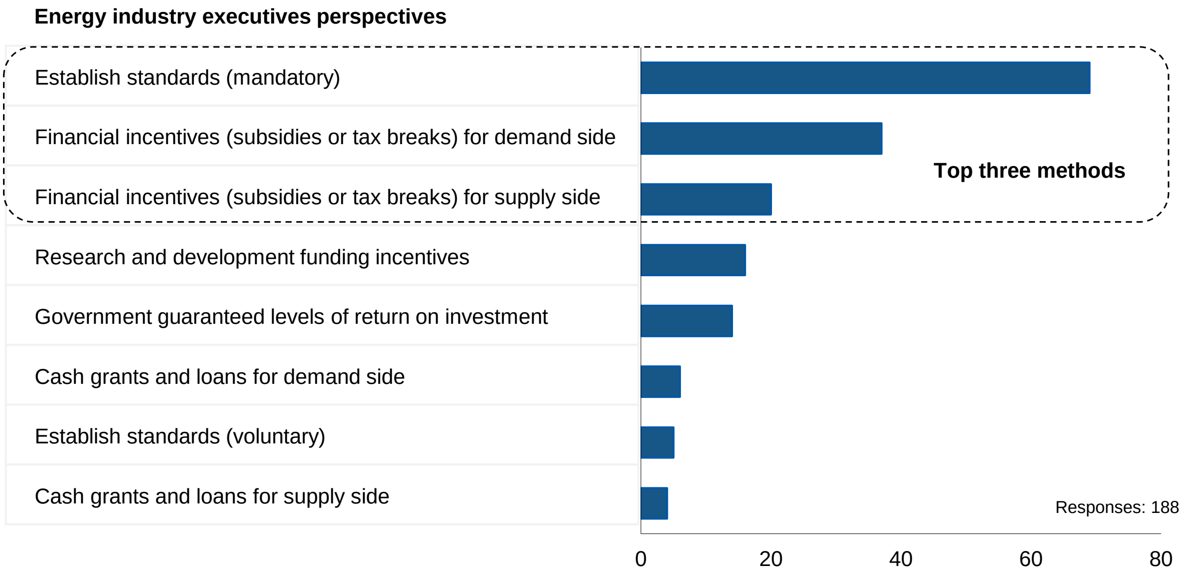
Another example of a negotiated program is the Chinese 1000 enterprise programme. This targets the most energy-intensive enterprises in China with the goal of improving energy efficiency. Large-scale enterprises included in the programme are in nine major energy-consuming industries: iron and steel, petroleum and petrochemicals, chemicals, electric power generation, non-ferrous metals, coal mining, construction materials, textiles, and pulp and paper. An overview of the programme is presented in Figure 15.

It is difficult to verify independently the estimated emissions reduction from the Chinese 1000 Enterprise programme. However, figures suggest that the programme has contributed to a considerable reduction of energy consumption and carbon emissions in the target enterprises. Some of these savings are likely to have resulted from simply increased attention to energy management, including the introduction of full-time or part-time energy managers, while other savings during the first year are likely to have come from the closure of small, inefficient production processes within enterprises. The programme has also raised awareness and changed the priorities of provincial authorities and executive management so that they focus on improving energy efficiency.[41]

The Japanese and Chinese programmes illustrate how a careful application of simple guidelines, energy management, and incentives and 'sanctions' can support negotiated agreements between public and private sectors to stimulate energy-efficiency efforts. The examples also highlight the importance of regulation, education,

Figure 16

Perspectives of energy-industry executives and WEC member committees on the most effective energy-efficiency policy mechanisms



WEC Member Committees perspectives

1. **Establish standards (mandatory) –** top-scoring method according to Member Committees to support energy efficiency in all energy sectors, except alternative energy production where it is viewed as of secondary importance
2. **R&D funding incentives –** viewed as a priority approach to support energy-efficiency improvements in all sectors – especially alternative energy production
3. **Financial incentives for supply side –** this was perceived to be the most important mechanism for alternative energy producers

Responses: 43

consideration of short- and longer-term issues, as well as the fact that sanctions and penalties must be socially and culturally appropriate.

Furthermore, the examples illustrate that negotiated agreements can support relatively ambitious objectives.[42] The analysis of the Japanese and, in particular, Chinese programmes exhibits their different characteristics compared to western negotiated agreements. Transferring lessons into other contexts is not straightforward given the unique government/industry relations in China and Japan, and other cultural and other context-specific factors.

Despite these policy successes in Japan and China, there is reason to believe that, as captured through the WEC perception surveys, negotiated standards may not be effective in all countries. As indicated in Figure 16, transparent mandatory standards may be better applied in some contexts.

WEC member committees and energy-industry leaders view mandatory standards as the most effective policy mechanism

Responses to the energy-industry and WEC member committee surveys largely agree on the most effective mechanisms for energy-efficiency policies (see Figure 16). However, the aggregate view on the key role of mandatory standards is likely to be biased towards western economies, giving further credence to the conclusion that the negotiated mechanisms of the Japanese Top Runner and Chinese Top 1000 programmes could face significant implementation challenges elsewhere.

- Establishing mandatory standards is viewed as the most likely mechanism to drive energy-efficiency enhancements. However, R&D is viewed as a top priority when considering alternative energy technologies. Alternative energy technology must be nurtured through innovative policy creation and mandatory standards implemented at a time when technology is mature enough to withstand such mandated progress.

- Establishing financial incentives is viewed as playing an important role in fostering energy-efficiency progress, which may be either supply- and demand-side tax breaks or subsidies. The survey highlights the importance of mechanisms that incentivise energy efficiency in the contexts of power generation, supply, transmission, and distribution. Energy-industry executives noted the value of subsidies and tax incentives, investment aids, and loans or grants with low interest rates and return rate guarantees.

- Voluntary standards and cash grants are not viewed as effective mechanisms to drive progress in energy efficiency. They may, however, play a supporting role in a much larger policy framework, as part of a policy-package approach.

Mandatory obligations on energy suppliers to invest in downstream energy-efficiency improvements

Demand-side management programmes have been implemented in a number of countries with various energy-market structures. Programmes focused specifically on household energy efficiency have been implemented in a number of European countries (e.g., Belgium, Denmark, France, and Italy) and vary widely in design.[43] They often include a suite of objectives including social, economic, and environmental goals. The main funding source is usually the public authority in charge of the corresponding policy or the utilities or energy suppliers (using energy savings obligation schemes).[44] One such example of a mandatory obligation to invest in energy efficiency imposed upon gas and electricity suppliers is illustrated in Figure 17; it is an example of efforts to overcome split incentives.

The UK Energy Efficiency Commitment (EEC) required electricity and gas suppliers above a certain size to deliver energy-efficiency measures to UK households. One half of the so-called ‘energy benefits’ from these measures had to come from a ‘Priority Group’ of low-income households, including ‘fuel-poor’ households, who spent more than 10% of their income on energy.

The mandatory obligations to invest in energy efficiency imposed upon gas and electricity suppliers led to long-term energy benefits. Energy benefits for low-income households were estimated to be 44% of the total, with more than 1.1 million low-income households receiving insulation measures. The scheme also provided substantial investment opportunities for the UK’s energy-efficiency industries, and helped encourage the transformation of key markets, for example, kitchen appliances.

There were a number of implementation challenges. One was about communication: the policy highlighted the need to reinforce the mandate with effective public communication programmes, so as to be sure all eligible households were reached. The second was about innovation: the policy was deliberately structured to enable energy suppliers to innovate in order to

Figure 17

Overview of UK Energy Efficiency Commitment

UK's Energy Efficiency Commitment (EEC)				
Goal	**Mechanism**	**Why it works**	**Key challenges**	**Evolution of mechanism**
• Reduce carbon emissions and energy consumption from UK households • Address fuel poverty (households who spent more than 10% of their income on energy) • Support energy-efficiency industry and improve energy security	• Mandatory obligation for gas and electricity suppliers to deliver energy-efficiency measures and benefits to UK households – benefits could include savings or improved comfort rather than reduced consumption • Efficiency targets were measured by 'fuel-standardised lifetime-discounted energy benefit'	• A well-established regulatory regime • Credible and clearly specified processes • Effective enforcement mechanisms to ensure compliance • Defined rules for trading • Cost recovery options for suppliers • Clearly defined commitment periods • Flexibility on type and location of energy-efficiency measure • Incentives for 'innovative' energy-efficiency measures[1]	• Customer awareness of programme • Administrative requirements of programme were considered onerous, e.g.persuade customers to implement measures, and negotiate with agents • Developing a standardised set of technical monitoring requirements • Monitoring *ex post* actual benefits • Maintaining a high level of compliance within scheme • Some of suppliers' measures were duplicated or distorted market	• Consider how to fund potentially greater investments as efficiency targets are raised. There are distributional implications since all gas and electricity consumers pay higher prices to fund energy-efficiency improvements in a minority of households • Develop *ex post* monitoring of actual energy savings • Implement standardised set of monitoring requirements • Clarify methods by which to deliver policy and benefits to avoid market distortion or excessive use of one mechanism

1. Forfori, F. (2006) "Evaluation of the British Energy Efficiency Commitment within the framework of the AID-EE project." Project executed within the framework of the Energy Intelligence Europe program, contract number EIE-2003-114. Ecofys. Accessed 28.03.2011.

meet the policy targets. However, in reality, many suppliers undertook similar and minimal approaches to meet their obligations; for example, the wide-spread distribution of discounted compact fluorescent light bulbs (CFLs).

'In the area of demand management, the main goal is to improve energy efficiency by promoting more efficient energy use by consumers, informing and educating customers and providing them with solutions to help them reduce the environmental impact of their habits and consumption patterns.'

WEC Survey 2011, Energy-Industry Executive

The UK example shows that there can be significant opportunities to invest in demand-side management programmes and low-carbon energy infrastructure as part of public initiatives to improve energy efficiency. But the private sector and policymakers must agree on how to implement these policies. Without a deeper understanding of industry expectations of the timescales for investment return, policymakers will face challenges in developing the industry-changing policies required for a low-carbon future. Furthermore, both sides need to understand and align on investment horizons for specific investments (e.g., efficiency, infrastructure, etc.).

The alignment is a two-way process and will require compromise from both policymakers and industry executives.

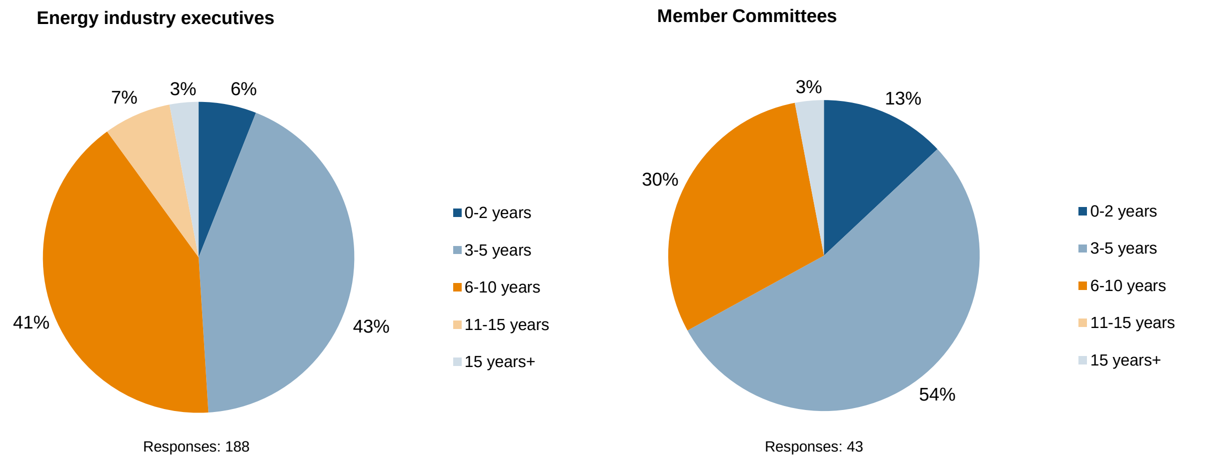
Summary

The number and ambition of energy-efficiency policies has grown considerably over the past two decades. The majority of WEC member countries have set up specific institutions dealing with energy efficiency, such as energy-efficiency agencies.[45] Policymakers are now in a position to draw upon a wide range of experience when designing and implementing such policies, and are becoming increasingly well-placed to identify 'what works' in encouraging energy efficiency in different markets and sectors.

The policy review demonstrates that it is possible to design policies for widely different contexts. These can successfully overcome non-price barriers to energy efficiency and deliver investments that contribute to environmental, social, and economic objectives. These policy mechanisms have been implemented in both developing and developed countries.

Figure 18

Perspectives of energy- industry executives and WEC member committee perspectives on acceptable timeframes for return on investment (ROI) for government-mandated efficiencies



Member Committees typically have a more optimistic timeframe for return on investment (ROI), with almost 70% saying that they believed the ROI should be achieved within five years or less, in contrast with only 50% of the industry executives.

There is no single policy mechanism to drive energy efficiency. Policy success is often dependent on effective governance, supporting institutional capabilities, and adapting policies to local circumstances. To date, there is little evidence that some policy mechanisms can only be applied in developed economies or only in developing economies.

Effective policy commonly requires a mix of initiatives working together in synergy to ensure that incentives to improve energy efficiency are supported by mechanisms that lower the transaction costs of improving energy efficiency. Without a combination of mechanisms, energy producers and consumers may not see the benefits energy efficiency. But while a diversity of approaches is likely to be required, care needs to be taken to ensure that individual policies complement one another rather than creating either redundancy or conflicting incentives.[46]

The energy-efficiency policies examined in this chapter share the following success factors:

- Strong political commitment over a sustained period of time
- Careful targeting to different types of energy user
- High level of trust in the regulator combined with transparency in standard-setting and implementation
- Clear benefits to participating energy users
- Flexibility and adaptability to changing circumstances.

Checklist for policy design and implementation: energy efficiency

Energy-efficiency policies can be targeted at consumers/residential households, industry, and energy suppliers, and all must be carefully implemented to ensure sustained changes in energy use. They include:

- Consider consumer behaviour as much as technologies in order to overcome price and non-price market limitations. Successful labelling and efficiency programmes apply a combination of information, awareness, and incentives to encourage consumers to adopt energy-efficiency practices and to promote ‘brand loyalty’ to efficient technologies.
- Apply a mix of supporting and complementary initiatives to overcome market barriers to energy efficiency. Effective policies must address the particular features of individual markets, the circumstances of different types of

household and organisation, and the multiple barriers to energy efficiency. Examples of supporting initiatives include information campaigns supported by direct subsidies plus financing methods.[47]

- Enhance and increase mechanisms that incentivise energy efficiency in the power generation, transmission, and distribution context. Regulators should consider approving rate recovery or implementing other kinds of recovery mechanisms that will incentivise energy efficiency by energy producers as well as end-users. In this context, regulators should consider the substantial capabilities of smart-grid technologies for achieving these objectives.

- Consider the evolution of any policy over time to ensure initial successes can be sustained. Consider both short- and long-term issues as initial successes may not be sustainable over time without high levels of investment for repairs and upgrading inefficient equipment. Programmes should include a comprehensive and coherent approach in which both near- and longer-term wins are considered.

- Monitor, update, and enforce regulations in response to evolving technology and markets. Regulators should develop to evaluate ex ante and ex post tracking of actual energy efficiency savings and to evolve policies that keep capturing efficiency gains once initial pay-offs have been achieved.

- Set simple and clear guidelines. Energy-efficiency policies can be applied in developing economies. Along with increased attention to energy management, simple and clear guidelines can have great results for energy-intensive industries in developing economies.

- Focus on educating industry and consumers to overcome split incentives and limitations on decision-making. Government can play a powerful role in educating consumers and business on available energy-efficiency options and the value of energy.

- Consider government-industry relations and the ‘right’ role for government. Differences in administrative cultures and public-private relations need to be taken into account. In some contexts, close relations between industry and government supports negotiated agreements. In other contexts, where leaner government and individual stakeholder integrity are highly prized, a similar scheme may be problematic due to perceptions of regulator intrusiveness; in this context, mandatory standards may be more effective.

- Consider direct and indirect rebound effects. Channelling the benefits of energy efficiency into more growth and greater consumption increases the risk of environmental impacts. Channel the benefits into lower-carbon energy supply and improved quality of life instead.

4. Meeting the financing challenge

'A stable, long-term regulatory regime with certainty of investment-return over the life of power assets is the fundamental basis for encouraging investment in energy infrastructure.'

2011 WEC Survey, Energy-Industry Executive

Significant investments are needed to maintain and replace energy infrastructure in developed countries, and to meet growing demand and increased energy access in developing countries.[48] According to the IEA, there is a global need for a cumulative investment of $33 trillion (year-2009 dollars) in energy-supply infrastructure over the period 2010-2035. Investment is required in oil and LNG terminals; oil, petroleum, and gas pipeline infrastructure; and electricity generation, distribution, and transmission. This amount represents approximately 1.4% of global GDP on average to 2035.

The electricity sector alone requires an investment of about $16.6 trillion, or half of the total projected investment to 2035. The electricity sector presents particularly important investment challenges due to its complex array of inter-related components, including power plants, transmission and distribution networks, and end-use equipment. Add to this the fact that decisions taken today regarding energy systems and infrastructures can have implications for decades into the future: for example, even in developed countries with an established nuclear infrastructure, it takes at least a decade from the decision to build a reactor to the delivery of its first electricity.

'Incentives, regulatory transparency, and sufficient policy information are indispensable for private firms' investment decisions.'

2011 WEC Survey, Energy-Industry Executive

The electricity system also represents the largest and fastest-growing source of CO_2. Yet it could support many of the options for a more efficient, less carbon-intensive economy[49]: for example, a focus on the effective end-use of electricity could play a key role in reducing the demand growth for energy; electricity generation may be easier to 'decarbonise' than other energy infrastructures (via use of natural gas, renewable sources of energy, nuclear, and carbon capture and storage); and it holds the promise of a major role in reducing emissions from heating and transport through the electrification of these services. A further layer of complexity is the need to ensure that energy is affordable in markets structured to attract the necessary large-scale investment electricity generation, transmission, and distribution.

The electricity sector highlights the balancing act facing policymakers: ensuring the security of energy supplies and the resilience of the existing energy infrastructures, while supporting a transition to low-carbon energy systems. Financing the renewal, replacement, and expansion of existing energy infrastructures is a clear need at the global, national, and regional level, and will require a wide range of public-private partnerships to mobilise the necessary level of investments. Countries use a range of policies to secure both domestic and foreign investment, and the selection is very much dependent on the market structure in a given institutional context. Examples can vary from India's Ultra Mega Power Projects Policy which is aimed at increasing private sector investment, to Argentina's Fund for the Investment Needed to Increase the Supply of Electricity in the Wholesale Market, to Canada's ecoENERGY for Renewable Power initiative to encourage investments in the supply of clean electricity from renewable sources like wind, biomass, and small hydro.

Policy review

This chapter examines a number of policy mechanisms introduced in a range of energy markets and economies around the world to support investments in energy infrastructures—both carbon-based and renewable. The policies examined include South Africa's Integrated National Electrification Programme, Germany's use of feed-in tariffs for renewable energy, the USA's capacity incentive mechanism in wholesale electricity markets, China's application of the Clean Development Mechanism, and the UK's Carbon Trust.

'The greatest regulatory framework deficiencies limiting investments are inconsistent regulatory frameworks, lack of incentives, and politicians who are not up-to-date on the latest technological developments'

2011 WEC Survey, Energy-Industry Executive

These policies are examples of mechanisms that tackle the issues of increasing electricity access, ensuring reliability of supply, and the development and integration of renewable energy into electricity systems.

Factors inhibiting or enabling energy-infrastructure investments

WEC member committees and energy-industry executives were asked to identify: a) the regulatory framework deficiencies that limit or stop a company from investing in a country's energy infrastructure; and b) what components of a regulatory framework encourage investment in a country's energy infrastructure.

Both industry executives and member committees noted the most inhibiting factors as:

- Lack of long-term, nationally unified, future energy vision, leading to uncertainties about long-term investment returns
- Absence of policy transparency and clarity, resulting in the private sector being uncertain of the implications of the policy for its companies' investments
- Unreliable, inconsistent, and uncertainty of regulatory regimes, leading to the private sector facing a future of uncoordinated and unpredictable policies

Policymakers can encourage private-sector investment with the following:

- Transparency, consistency, clarity, and stability in regulatory regimes and policy creation, to enable companies to plan long-term, stable cash-flows
- A participatory regulatory process, so private-sector perspectives can be aligned with those of policymakers
- Legal security and enforcement procedures, to enable legal recourse and to secure medium- to long-term investments and company assets
- Assurance of the possibility of achieving long-term investment return, by developing stable, long-term policies

The survey findings highlight the policy characteristics that establish an attractive risk-reward environment for energy investments and generally support public-private partnerships. Policymakers, through clear and stable policies can, at low cost, reduce the regulatory and policy risks associated with long-term, high-capital investment projects by the private sector. These two risks are key challenges for the private sector and are very difficult to price or insure against. Reducing regulatory risk will support the private sector in bringing much needed capital to public-private partnerships.[50]

'[a] successful financing mechanism should either accelerate the payback on an investment (usually reducing it to an acceptable level), or it should assist in reducing the amount of capital needed in the first place'

2011 WEC Survey, Energy-Industry Executive

Increasing access to electricity

South Africa's Integrated National Electrification Programme (INEP) was initiated in 2001, and arose from several years of electrification initiatives that had been led by the national electricity utility, Eskom (see Figure 19). Electrification was already on South Africa's national political agenda from 1991-94, as the country transitioned to a democratically led government. The new government, elected into power in 1994, continued to support electrification efforts, and the programme was transferred to a government department in 2001.

The INEP offers a pool of government funds for regional and municipal governments to increase electricity access and grid connection. Dedicated financing for the INEP has been one of the key factors in the programme's rapid electrification rate. Since 2006, additional financing has been channelled to the poorest regions and initiatives, for example, through the Free Basic Electricity programme (i.e., the first 50 units consumed each month are free). This helps ensure the least well-off have access to electricity.

The programme has offered benefits beyond providing affordable electricity access. At the aggregate level, socio-economic conditions have improved as a result of job creation and capacity building. Over 32,000 jobs have been created since 2001 (although some may be temporary), and over 6,900 people were trained from 2005-2009. Overall, the access to electricity in South Africa has risen from approximately one-third of the population in the mid-1990s, to over 80% of the population today.[51]

South Africa's success in significantly increasing electricity access was partly due to several unique factors. The country benefited from access to capital (both Eskom's original commitment and then the government's funding); access to skills; access to an existing supply infrastructure; and natural resources including coal reserves. Further, the market provided by its highly intensive energy industries initially helped subsidise the electricity expansion programme. The country benefitted from the presence of its strong energy utility, Eskom, with its associated managerial and technical skill sets and capital surplus. Finally, it should be noted that the democratic transition in the early 1990s provided not only a fundamental shift in the political landscape, but also an unusual institutional

Figure 19

Overview of INEP programme in South Africa

South Africa's Integrated National Electrification Programme (INEP)				
Goal	**Mechanism**	**Why it works**	**Key challenges**	**Evolution of mechanism**
• Provide universal access to electricity by 2012 through grid connection and off-grid connection with a focus on households, schools, and clinics • Develop off-grid options in cases of necessity – in particular solar power	• Direct government funding through state-owned firms or through provision of subsidies to private firms (e.g., as grants and tax breaks) • State grants or loans or grid connections • Monthly 50 kWh of 'Free Basic Electricity' to support the poor and make electricity more affordable • Subsidised solar-power installations for off-grid connections	• Dedicated financing for the programme • Necessary governmental institutions • Strong policies and top-down approach • Ability to fund state-financed schemes where cost recovery may not be essential • Ability to mobilise and train a work force to support and execute programmes • Implementation of new technology, e.g., pre-paid electricity meters to quickly bring consumers into the system	• Requires robust economic development and governing structures to support programme • Power shortages and blackouts due to the country's increased electricity demand • Connecting rural areas to grid and use of costly non-grid solar power if necessary • Keeping administrative costs low to aid programme affordability • Very strong project management capabilities required for the national programme • Consumer preferred to be connected to the national grid and this delayed consideration and application of alternative solutions	• Elements have been adopted in China, India, Botswana, and Brazil (e.g., pre-paid electric meters) • Consider use of an agency rather than government departments to drive and manage programme • Embed electrification programme within an overall national "energisation" vision that incorporates and optimizes all forms of energy (electric, gas, renewables, etc.)

environment for policymaking. Energy access was seen as closely linked to supporting the new democracy and continued economic development, and this helped create urgency for the programme.[52]

As well as these unique elements noted, this example also provides some transferable lessons. Countries need to consider whether they have the necessary supporting components to implement this mechanism. These components include the ability to dedicate financing, effective institutions, clear policies, and the ability to mobilise and train a work force to carry out electrification. The presence of these factors in the local context must be carefully considered when designing electrification programmes.

'Strategic alliances between government, the banking sector, and the private sector to establish financing mechanisms, with government incentives and low interest rates, in exchange for projects that ensure job creation and economic, social, and environmental sustainability.'

2011 WEC Survey, Energy-Industry Executive

Other lessons include the effective application of new technologies. The electrification efforts used pre-paid electric meters. These supported programmes such as the free, basic electricity for eligible consumers and enabled cash flow for the programme. The technology also helped new users begin to understand electricity as a product and manage its use. The technology and underlying concepts were subsequently leveraged by other industries, such as pre-paid mobile phones.

The INEP also suggests that an agency model may be more effective to drive large-scale electrification efforts rather than a government department. At its heart, the electrification programme relies on robust project management, technical skills and nimble decision-making. Government departments are generally better positioned to set targets, monitor progress, and establish appropriate incentives.

A final learning is the need to embed electrification efforts within a broader national 'energisation' programme in which all forms of energy are optimised. Policymakers need to consider how to provide energy to its people and economy in the best possible way. Connecting to a national grid per se is not necessarily the best use of available technology and energy resources.

Figure 20
Overview of the PJM capacity incentive mechanism

Pennsylvania, New Jersey, Maryland (PJM), USA Reliability Pricing Model (RPM)				
Goal	**Mechanism**	**Why it works**	**Key challenges**	**Evolution of mechanism**
• Incentivise investment in new generation capacity, grid improvements and interconnection • Ensure peak demand can be met • Maintain a reserve margin for unforeseen generation and transmission capacity losses	• An annual forward market organised through a centralised competitive auction to encourage investments in new and existing electricity generating capacity with a three-year procurement capacity • Price for capacity is set by a variable resource requirement	• RPM factors market power into its design by considering variability in resource location, time, and availability • Avoids rewarding generators with 'windfall' gains and does not support investments that breach the cost of service regulation • Demand-side resources to compete with supply-side resources to reduce incentives to over-invest in plants • Capacity payments adapted to promote low-carbon resources • System reliability is preserved by a backstop mechanism to ensure sufficient resources • Limitations on transmission system is reflected by locational pricing for capacity	• Ensure large generators do not deliberately withhold capacity resources and increase their bidding prices, resulting in power shortages • System Operators (SO) play a crucial role for supplying money that cannot be recovered from energy spot market – ensure design requires high dependence and trust in the SO to adequately set capacity resource quantity and type[1] • Electricity prices must reflect costs to ensure system stability	• Enhance capacity payment designs to integrate additional environmental components including energy efficiency and renewable energy targets • Increase membership to the scheme to cover a larger transmission system and more system generating assets

1. Newell, S., Spees K., Hajos, A. "Midwest ISO's Resource Adequacy Construct: An Evaluation of Market Design Elements" Retrieved March 21, 2011 from *The Brattle Group* http://www.brattle.com/_documents/uploadlibrary/upload832.pdf

Ensuring reliability of supply

Capacity payments are incentive mechanisms to compensate electricity generators for improving the reliability of the system and security of supply. The concept behind these schemes is that the payments are based on capacity made available vs. energy actually supplied. In addition, the payments provide sources of revenue that compensate generators for the benefits additional capacity brings to system reliability.[53] These payments thus enable generators to recover investment costs and invest in additional capacity in wholesale electricity markets. Overall, capacity payments, when properly designed, can provide the needed revenues for investments required to meet reliability targets, as illustrated in Figure 20.

The Reliability Pricing Model (RPM) is an example of a capacity market implemented in 2007 by PJM (Pennsylvania-New Jersey-Maryland), the regional transmission organisation in the northeast region[54] of the USA. The capacity incentive mechanism was implemented in this wholesale electricity market to ensure that peak demand can be met, and to maintain a reserve margin for unforeseen generation and transmission capacity losses.[55] The mechanism is a quantity-based system, in which capacity obligations are traded. Capacity obligations are defined as the 'expected peak monthly loads plus a reserve margin'. Load Serving Entities (LSEs), or distributors who sell electricity to consumers, must meet these capacity obligations.

In the PJM area, not all Load Serving Entities (LSEs) are utilities, nor do they all necessarily own generation plants. Thus, LSE capacity obligations can be satisfied if LSEs can purchase 'capacity', i.e., meet their capacity obligations, from other utilities and generation companies. Under the Pennsylvania, New Jersey, and Maryland systems, an annual auction, held three to four years in advance of when availability is required, is used to sell capacity. Given this lead time, newly constructed capacity (and equivalent demand-side responses) can enter the market and counteract potential efforts by existing generators to exercise market power by withholding capacity.

In terms of potential unintended consequences with this policy, care must be taken when designing and implementing capacity markets to ensure compensation does not promote capacity-withholding during peak times, leading to long-term system instability. The RPM addresses market-power issues by factoring in resource quantity, location, time, and availability to better reflect the value of capacity under certain conditions. The forward-capacity market permits demand-side resources to compete with supply-side resources, with demand-side resources including end-users adjusting their energy demand according to the time of day or year, increasing energy efficiency, and generating electricity on-site.[56]

Promoting renewable power generation

Feed-in tariffs

Feed-in tariffs (FIT) policies are the most widely applied policy instruments to promote renewable energy in the world. Other instruments for stimulating the deployment of renewable energy include quota-based incentives, financial/tax-based incentives, or direct investment. However, of the 73 countries[57] with renewable energy targets, 45 countries and 18 regional localities have applied FITs to help meet their policy objectives.[58] Basically, the policies provide a set price for energy provided to the grid from renewable energy sources. Germany's FIT (see Figure 21), has helped establish one of the most advanced renewable-energy technology sectors in the world. The guaranteed price for renewable energy, as stipulated by Germany's FIT, has been instrumental in expanding the share of renewable energy in the overall gross electricity consumption from 3.1% to 16.8% in 2010.[59]

As the German example illustrates, FITs can be customised to promote the development of renewable energy across the country. This is done in Germany by setting differential tariffs for areas depending on wind resources, which encourages the development of generation facilities of a certain size, and specific renewable-energy technologies.

'To reach a low-carbon energy model, two key issues should be urgently addressed worldwide, which will substantially contribute to improving the competitive position of renewable energy: the elimination of subsidies to fossil fuels, and the internalisation of CO_2 costs. Further compromises in these matters should be made by government.'

2011 WEC Survey, Energy-Industry Executive

Evaluating the EEG (German Renewable Energy Act) by its impacts on end-user costs alone does not represent FIT's full benefits. These include developing sustainable energy supplies, lowering the external costs of the energy supply, and increasing energy security by reducing reliance on imported energy.[60] Renewable-energy technologies are viewed as a valuable export industry, as well as a growing domestic industry that is encouraging the development of a skilled labour force. However, the employment effects of the EEG are viewed as highly controversial: the overall loss of purchasing power and investment capital due to higher electricity prices causes negative employment effects in other sectors.

Although FITs can be very effective in promoting renewable energy, improperly applied policies can create cost problems and promote inefficiencies and instabilities in the system. The business case for implementation of renewable-energy sources,

Figure 21
Overview of the German FIT programme

Germany' s application of feed-in tariffs				
Goal	**Mechanism**	**Why it works**	**Key challenges**	**Evolution of mechanism**
• Incentivise investment in renewable energy generation • Develop energy supply in a sustainable manner • Lower external costs of energy supply • Increase energy security by reducing reliance on imported energy	• Fixed feed-in tariffs (FITs) are production subsidies that guarantee prices for electricity production, usually set at a premium, for renewable energy producers	• Guaranteed grid access • Customized to promote even development of renewables by setting differential tariffs for areas depending on wind resources • Differentiated tariffs to reflect costs of various renewable energy technologies at certain developmental stages to support the development to commercial scale	• Requires an organized governing system along with supporting institutions in place • Setting appropriate tariffs to avoid 'bubbles' and inefficient electricity generation at high-costs • Ensuring system can integrate renewable energy, e.g., grid expansion, power storage systems to help with the integration of renewable energy into the grid • Ensuring demand side management programmes to help balance intermittent renewable energy electricity production	• Development of a systemic view of the renewable scheme that encompassed more than just generation • Promotion of increased [over-]capacity when fluctuating renewables constitute a significant fraction of generation assets • Renewables need to begin to offer system-wide services, e.g., grid, demand responses, storage • Liquid intraday markets to support renewables integration

unlike more traditional generating assets, calls for a more robust consideration of the requirement for additional infrastructure, including grid access, storage and transmission. For example, the locations of wind farms are largely driven by considerations of the strongest wind corridor. But these locations may require grid connections that are inefficient in terms of distribution, and lead to bottlenecks in transmission infrastructure.

As the share of renewables increases in the energy mix, the stability of the energy system suffers. Fluctuations in supply occur, reflecting the times at which the renewable assets are able to generate power. To enhance system stability additional capacity is needed, often in the form of Combined Cycle Gas Turbine (CCGT) facilities. However, there are indirect effects on CCGT runtimes: renewable-energy sources are prioritised according to the FITs, and this leads to CCGT facilities running inefficiently as they try to recoup investments. In some countries it has been determined that there is little incentive to develop competitive generation facilities as prices are fixed over the long-term. There is also substantial concern about the local climate effects from large-scale land-use in renewables projects.

Effective leverage of renewable-energy technology requires the energy industry and policymakers to align on renewable-energy adaptation throughout the value chain. In many cases this is likely to require significant capital investment in high-voltage transmission lines. These transmission lines are likely to offer reduced line loss and enable long-distance transmission of power from the most effective position of renewable-energy assets. While the costs will be significant, the long-term benefits to system efficiency and stability are expected to be great.

For FITs policies to be effective there must be an organised governing system along with supporting institutions in place. Another critical factor is the design of tariffs structured to cover the overall system (e.g., back-up system, infrastructure, system management etc.). At a systems level, there must also be a dispatchable back-up system to ensure stability, and a single, integrated network to avoid network conflicts, bottlenecks, and capacity shortfalls.

The worldwide implementation of FIT attests to its transferability and effectiveness in promoting renewable-energy development. However, unforeseen adjustments to the FIT framework can lead to an unstable market environment, just the opposite of what this policy instrument is intended to achieve. Where technology prices are uncertain and in situations of high price volatility, it can be difficult to fix feed-in tariffs at a correct level. Price-setting is key to creating a successful policy, as the ideal price will stimulate the market demand necessary to fulfil national renewable-energy targets, while avoiding market distortions, inefficient electricity generation, and inability to integrate renewables into existing infrastructures.

Figure 22
Overview of the application of the Clean Development Mechanism in China

China's application of Clean Development Mechanism (CDM)				
Goal	**Mechanism**	**Why it works**	**Key challenges**	**Evolution of mechanism**
• Stimulate sustainable development and emission reductions in developing countries, while giving industrialised countries flexibility to meet their emission-reduction limitation targets under Kyoto Protocol	• A project-based credit mechanism through which CDM emission-reduction (or emission-removal) projects in developing countries can earn certified emission-reduction credits. • Saleable credits can be used by industrialised countries to meet a part of their emission-reduction targets under the Kyoto Protocol • A 'taxation' system applied by China to Certified Emissions Rights that must be paid as a compulsory fee and used to sustain an ad hoc climate change fund	• China developed nationally based strategies to apply CDM mechanism within international programme • Supported by appropriate national administrative and institutional capacities • Strong national oversight of projects linked to local level • Integrated CDM investments with policies for energy, socio-economic development, environmental protection, and climate-change mitigation	• Cannot be effectively applied in least developed countries where weakness of political and administrative environment is generally incompatible with organisation of a sound system to attract CDM projects • Limited use in least developed countries with low CO_2 emissions (in terms of total, per capita, and historical emissions), and therefore provide fewer investment opportunities for foreign investors	• A worldwide adoption of CDM may facilitate its transformation in a global financial instrument - e.g., enlargement of CDM application to 'Annex 1' countries as well as giving the right to directly invest in CDM Certified Emissions Rights purchases to non-Annex 1 actors*

* There are 41 countries classified as 'Annex 1' in the Kyoto Protocol. These are classified as industrialized countries and countries in transition. Annex I countries have ratified the Protocol have committed to reduce their emission levels of greenhouse gasses to targets that are mainly set below their 1990 levels. They may do this by allocating reduced annual allowances to the major operators within their borders or if they offset their excesses through a mechanism that is agreed by all the parties to UNFCCC. The CDM is one such mechanism.

However, prompt government action to adjust tariffs can help to minimise negative effects while continuing to instil confidence in the long-term stability of the renewable-energy market.

Clean Development Mechanism

The Clean Development Mechanism (CDM) is part of the Kyoto Protocol to the UN Framework Convention on Climate Change. It was designed as a tool to enable industrialised countries to fulfil components of their carbon emission reduction goals[61] in a cost-effective way, while at the same time contributing to the sustainable development of other countries.

The CDM is a project-based, market-driven, and bottom-up mechanism, where each project is independently designed and proposed by the project owner, with or without the presence of a Certified Emissions Rights[62] (CERs) buyer during the project-design phase. Each CDM project, before being approved by the CDM Executive Board[63] (which assesses the reliability and accountability of the project), must be approved by the Designated National Authority (DNA) of the hosting country.[64] DNA approval is discretionary, and each DNA can define a set of rules and regulations related to the approval of projects—allowing it to specify the types of CDM projects to be developed in its country. To date, China is the country most successfully using the CDM, adopting a set of specific actions to attract as many investors as possible, and in adapting the CDM to its specific national needs and policies.[65] There are over 1,000 CDM projects hosted already in China, the majority involve the production of electricity, including more than 560 hydroelectric projects and more than 320 wind-energy projects, and it is estimated that total investment reached approximately $60bn.[66] Figure 22 gives an overview of the CDM in China.

The application of CDM in China shows the benefits of integrating CDM investments with energy, socio-economic development, environmental protection, and climate change mitigation. For example, the large number of hydroelectric projects, the majority of which are small- to medium-sized dams and hydro-plants in rural areas, have contributed to rural electrification programmes, and thereby avoided the use of more polluting energy sources such as coal. In particular, the CDM has played a significant role in the development of the electricity system in China[67] and especially the Chinese wind-energy sector. CDM has also been used to increase coal-mine

Figure 23

Overview of the UK Carbon Trust

UK's Carbon Trust (CT)				
Goal	**Mechanism**	**Why it works**	**Key challenges**	**Evolution of mechanism**
• Promote innovation and commercialization of low-carbon technologies	• Financing through direct government grants though a government-established independent not-for-profit company • Develops low-carbon innovations by issuing R&D grants • Helps in creating new low-carbon businesses and financing clean-energy technologies firms • Provides information, insights, and management guidance • Initiate joint ventures and collaborate with private sector to leverage a diverse pool of project expertise	• Independence from government helped build Carbon Trust brand • Focus on commercialization of technologies • Provides grants for applied research based on commercial needs rather than academic and theory-oriented research • Fast-track mechanisms accelerate technologies from pilot stage to a commercial scale where they might quality for large-scale development funding • Technology accelerators fill a specific gap for funding emerging low-carbon technology research	• Requires financial resources and institutional and business capacity to execute • Financing through direct government grants. Substantive and prolonged funding is required for success • Majority of its funds are still sourced from government, which is one of the model's major weaknesses • Requires significant independence governance and a market-oriented approach to operate effectively • Can be challenging to remain truly neutral on which technologies to support	• Develop Carbon Trust as a brand that can be used to franchise model • Development of global networks of Climate Innovation Centres to allow application of model to developing countries

methane recycling, and contributed a reduction in the number of mine accidents in the country.[68]

The Chinese model for the CDM application is partially influenced by the unique political system of the country. That noted, a similar model seems possible in other fast developing countries with energy security, environmental issues, and socio-economic development needs. For example India, Latin American and Asian countries (i.e., Brazil, Mexico, Argentina, Indonesia, Thailand, Malaysia), as well as the Middle East and some African regions (i.e., South Africa), could benefit from the adoption of ad hoc CDM-related national rules relating to national policy priorities.

Stimulating low-carbon technology innovation

The UK's Carbon Trust is an independent organisation established by the UK government. It offers support for businesses and the public sector to reduce carbon emissions, commercialise low-carbon technologies, and increase energy efficiency (see Figure 23). The company's services are categorised into insights (identifying the financial effects of climate change and informs policymakers and business leaders); solutions (providing services and support to help businesses and the public sector to reduce carbon emissions); and innovations (developing low-carbon innovations by issuing research and development grants).[69] In addition, the Trust helps create new low-carbon businesses by generating and developing ideas, overcoming market barriers, providing management support, and financing clean-energy technologies firms with internal funds and leveraged private funds.[70]

In a little more than a decade, the Carbon Trust has expanded from a UK initiative into an internationally recognised model, which has been successful in both promoting low-carbon initiatives in businesses and energy efficiency, and supporting emerging low-carbon technologies. The Carbon Trust's overall initiatives are estimated to save an average of up to 2.3 $MtCO_2$ per annum.[71] In addition to the direct carbon emissions-reduction activities, the Carbon Trust has expanded its experience into other markets including China, the USA, Australia (which has fully implemented the model), and the Middle East. These partnerships also give a glimpse of the partnering country's needs, which can help the Carbon Trust to identify areas for future policy-transfer cooperation.

These examples indicate that the Carbon Trust's model is transferable to other jurisdictions, and that international interest in this approach to stimulating a low-carbon economy is continuing to grow.

The strength of the Carbon Trust model lies in its flexible bottom-up initiatives, strong ties in the business community, and rapid deployment capabilities. Its largely top-down funding approach requires governments to provide dedicated funds over an extended period of time, which can be viewed as the model's major weakness. However, countries that can mobilise the private sector to provide finances can diversify the funding stream to reduce reliance on government revenue. The bottom-up implementation approach, which requires a certain level of capacity development, is effective in targeting specific areas that governments may wish to develop. These may include low-carbon and emerging renewable-energy technologies. Given the requirement for funding, the Carbon Trust model is likely to be restricted to wealthier countries for the time being.

Summary

'There will be no need for extraordinary financing measures if all sectors can see the benefits of investing in energy efficiency and sustainable urban mobility.'

2011 WEC Survey, Energy-Industry Executive

Investment is a long-term process—especially for energy infrastructures, which can take decades to develop. Barriers and challenges posed by public opposition, land-use planning restrictions, and grid-connection problems may prolong this process even further. For example, renewable energy-deployment programmes have sometimes been slow to deliver results due to the time required for learning and scaling-up processes.

The policies in this section show some of the variety of mechanisms that can be used to stimulate investment. Direct government spending is clearly an option in some cases, either through state-owned firms or through the provision of subsidies to private firms (e.g., as grants and tax breaks). In many other cases, governments are implementing policies that provide incentives for the private sector and other actors to invest in competitive markets. In the electricity sector for example, many countries have shifted towards a more liberalised model in which power generation (and sometimes supply to final consumers) is open to competition. Internationally, there is a lot of variety in the design of these markets, and in their approaches to fostering sufficient new investment to meet demand.

The policies above also provide examples of competitive market mechanisms set up by governments. Competition between renewable-energy project developers and equipment manufacturers has been stimulated to some extent by Germany's feed-in tariff mechanism. In South Africa, competition has been used in bidding processes for concessions to provide off-grid electricity. Internationally, the Clean Development Mechanism (CDM) is an example of investment directed to low-carbon projects in developing countries.

Given the scale of the necessary investment in energy infrastructure, public-private partnerships will be essential to attracting private investment in major public infrastructure projects. The partnership structure offers a number of benefits, including flexibility from the possibility of securing diverse sources of up-front finance and funding, and risk sharing (between public and private partners), where levels of risk may otherwise erode the net present value of low-carbon projects. In particular, the partnership structure is effective where projects are hard to finance on purely commercial terms. This can include instances where technology is deployed for the first time in a country (even if successfully demonstrated elsewhere); where a government faces the challenge of simultaneously developing infrastructure, policy frameworks, and supply chains; or in the case of pilot or demonstration projects for newer technologies.

Although market-driven policies have become increasingly common in the last two decades, this does not necessarily mean a small role for governments and regulators. In many of the market-driven investment examples, governments and public bodies play an important governance role. Where public-private partnerships are used, it will be important for governments to be active participants, co-funding projects and ensuring that they are aligned with national development priorities and implementation plans. Early dialogue between governments and potential private sector partners is essential to ensure alignment and adequacy of funding levels. This underlines the importance of engaging business in the process of strategic planning of national infrastructure.

Regardless of the role of government or the structure of the public-private partnership, there are usually financial implications for energy consumers—either through taxation or through their energy bills. Therefore, even if public spending is not used, debates about the willingness of citizens to pay for the costs of these investments (and for the costs of alternative investments if such policies are not implemented) are very important.

‘The most efficient mechanisms provide regulatory certainty and make sure that regulators understand that investing for future growth is a legitimate investment. We must be allowed to invest for growth, not only for customers that exist today’

2011 WEC Survey, Energy-Industry Executive

A final important theme is the need for learning. In some of the policies reviewed, learning has led to periodic revisions; in others it has enabled the transfer of a policy between jurisdictions.

Checklist for policies design and implementation: innovative financing mechanisms

Energy investment policies include a range of approaches, and there are many lessons and insights for regulators as they consider ‘what works’. The following is a checklist of critical factors to consider:

- Provide a clear, well-defined and stable energy policy to reduce the risk of long-term investments by the private sector. Energy infrastructures take decades to develop and most energy-related investment, small-scale and large, will continue to come from private sources. Private investment needs a stable policy framework and reasonable predictions of financial outcomes if it is to invest at the scale necessary to meet the growth in global energy demand.

- Apply lessons and periodic policy revisions. Ineffective policies, or those with unintended consequences, must be adjusted without creating disincentives to long-term investment. Similarly, policies must be adjusted as they are transferred to other jurisdictions according to the lessons that have been learned.

- Apply a range of mechanisms to stimulate investment. In some instances (e.g., to develop economies, to encourage new renewable-energy infrastructure, or to support technologies for carbon capture and storage), direct government spending is an option, either through state-owned firms or through the provision of subsidies to private firms (e.g., as grants and tax breaks). In many other cases, more effective mechanisms may be policies that provide incentives for the private sector and other actors to invest in competitive markets.

- Determine the most effective role for government—even with market mechanisms. Government 'intervention' in markets and other activities will be needed if the urgency of the climate-change problem is to be properly acknowledged and tackled. Governments and public bodies play an important governance role in the design and implementation of rules and market arrangements.

- Facilitate a dialogue with citizens to ensure public funding is sustainable and considered equitable. Even where governments have chosen not to use direct spending to finance investment, tax payers will often end up paying the costs via their energy bills. Therefore, even if public spending is not used, debates and broad public support to pay for the costs of these investments (and for the costs of alternative investments if such policies are not implemented) are very important.

5. Takeaways for policymakers

Examples of unequivocal success are hard to find in the real world of energy policy; the transfer of instruments into other jurisdictions is a process of translation and adaptation of lessons. Lesson-drawing is ‘best considered as a creative act, rather than as a process of copying’.[72] Cooperation and the exchange of ideas between energy policymakers from different countries is extremely valuable in stimulating processes of policy learning. As highlighted by the analysis of the Energy Sustainability Index in Chapter 1, countries in very different regions may, in fact, share energy performance and contextual similarities, and be facing the same energy-policy challenges. Such implicit commonalities suggest that there is scope for shared policy lessons between countries and opportunities to jointly develop potential solutions.

Only through sharing policy experiences can the usual limits on decision-making be broken down, and lessons learned and implemented. Policy experiences and information are key to tackling the challenges of achieving global energy sustainability—a problem that requires unprecedented coordination and investment. The policy review revealed the following general findings for policymakers.

- Effective elements of policies can be transferred across regions, between countries with different levels of economic development and diverse policymaking regimes. Institutional and governance capacity, political commitment and public opinion are more important than differences in geography, energy reserves, population size and other factors.
- Institutional differences play a major role in potential policy transfers to other jurisdictions. For example a strong national energy policy instrument in one country will be difficult to transfer to another country if that country has a federal system. In Canada, the provinces are in charge of energy policy and the exploitation of natural resources, while national energy policy plays a limited role. In this political structure, policies at the sub-national level play an important role, and some provinces or states are frontrunners in introducing new policies. Institutional differences are also important when considering the transfer of policies from non-democratic/autocratic regimes to democracies.
- The problem structure is an important factor. For example, the political dynamics around carbon taxation or renewable-energy technologies in resource-rich economies such as Canada, Nigeria, or Australia are very different from those in countries without substantial fossil-fuel reserves, such as Japan, Italy, or Denmark.
- The market structure of the energy sector and the degree of liberalisation can have an impact. However, while this is an important factor, it is important to note that a variety of instruments (e.g., promoting energy efficiency or FIT) can work under a range of market structures.
- Different levels of socio-economic development play a role. For example, the capabilities and funds needed to implement the ‘Carbon Trust’ model (described above)

successfully are more likely to be found in more-developed economies, with access to finance as well as technological capacity in low-carbon technology development. However, recent initiatives indicate that with the necessary funding in place, capacities can be built up quickly in regions not formerly known for their expertise in this area (see e.g., the Masdar Initiative of Abu Dhabi with its focus on clean and renewable energy-technology development). For policy instruments that do not have strong public resource or capability requirements, such as congestion charging in a mobility area, diverse levels of socio-economic development seem to be less important in assessing the potential for transferability. Here, local contextual factors such as political commitment, public opinion, or feasibility are more important.

- The creation and implementation of new policy instruments are often historically contingent and can dependent on a 'window of opportunity'. These moments arise for a variety of reasons (e.g., change in government, crisis events, change in public opinion) and are often utilised by policy entrepreneurs. The transfer of a policy instrument from one jurisdiction to another often requires the opening of such 'windows of opportunity'—for example, international climate negotiations.

Key takeaways for policymakers

Possible interactions between instruments:

- Energy policymaking is a complex area with multiple objectives. These will sometimes be in tension with each other and cannot always be pursued simultaneously.
- Energy debates are often highly political. Policies to meet particular objectives can create winners and losers, and are often controversial. As a result, the process of implementation often involves compromises, and the modification of policy instruments to make them more politically feasible.
- Successful policies will build on an open dialogue regarding potential trade-offs among multiple goals, multiple time periods and multiple participants. Policymakers must be transparent and explicit about the trade-offs involved in establishing a policy and why any proposed trade-offs are appropriate in order to gain acceptance and investment by relevant stakeholders. Furthermore, this supports tracking of policy effectiveness and adaptation as conditions evolve.
- Introducing new policy instruments on top of existing policy instruments typically involves synergies and trade-offs. These need to be analysed in advance to avoid 'perverse incentives' and policy failures.
- Unintended consequences (even of policies that are working well) can, obviously, never be known in advance. There is therefore a

need for continuous re-evaluation and review of policy instruments after implementation.

Complexity and coordination across multiple jurisdictions and energy-policy domains:

- Multiple levels of government are involved in aspects of energy policy. Different levels of government have their own responsibilities, competences, and opportunities to contribute to sustainable energy policy.
- Coordination is needed across at least three dimensions: policy instruments, jurisdictions, and local, state, and national government levels.
- Models for successful coordination vary according to institutional set-up.
- Learning from previous examples in their own countries and internationally can help energy policymakers to deal with this challenge

Transferability of 'best practice' policy instruments:

- There is a need for more rigorous evaluations of energy-policy instruments in order to obtain more reliable evidence on what works, and what pitfalls to avoid.
- There are no single, 'silver bullet' instruments: the complexity of the challenges, the multiple actors and interests involved, as well as the multiple policy objectives to be achieved creates the need for mixes of policy instruments. Policymakers must assess possible trade-offs and synergies between these instruments, and also identify potential conflicts and redundancies.
- Potential obstacles for policy transfer need to be considered. Important factors include differing energy market structures, different levels of socio-economic development, different institutional structures, and different resource endowments.
- It is necessary to translate global findings about successful policy instruments into local arrangements and settings that work. This translation works best as a dialogue between international energy-policy experts, industry executives, and stakeholders and policymakers from the appropriate jurisdiction.

6. Key challenges

As well as reflecting on the policy implications of this report, it is also important to outline the main energy-policy challenges going forward. This report supports the statement that there is no single 'silver bullet' solution for energy sustainability and related issues, and that the most effective approaches will vary from country to country. Policymakers and energy-industry executives must, in discussion with consumers and citizens, determine effective solutions to the issues listed below:

- Attracting large-scale investment in new low-carbon electricity-generation sources and associated transmission and distribution networks, together with more sustainable transport infrastructures
- Ensuring the security of energy supplies and the resilience of energy infrastructures so that energy is both available and affordable during the transition to low-carbon energy systems
- Encouraging the research, development, demonstration, and deployment of low-carbon technologies, requiring substantial financial support targeted at specific technologies over extended periods of time
- Using a variety of measures to overcome non-price barriers to energy efficiency in industry, households, and the public/commercial sector, while at the same time using broad-based carbon taxation or cap and trade schemes to prevent energy savings being undermined by rebound effects
- Reducing the demand for mobility services through measures such as effective urban planning, demand management, and information and communications technology, together with progressively reducing the dependence of the transport system on liquid fossil fuels
- Careful analysis and coordination of policy instruments to ensure challenges are addressed without negative interactions and perverse outcomes by acknowledging these challenges cannot be addressed by single fixes
- Imposing progressively more stringent carbon taxes or cap and trade schemes, ultimately covering all emitting sectors; while these are necessary components of the policy mix, they will be insufficient to encourage the transformational changes that are required
- Encouraging a wide and open societal debate about which kinds of energy systems are required to fulfil people's needs for mobility, heat, and electricity services in the medium- to long-term future, while at the same time ensuring environmental sustainability; this will necessarily involve some difficult trade-offs
- Extending policy horizons and designing policy interventions to be consistent with ambitious long-term goals for emission reductions. Since energy systems and infrastructures are capital intensive and long-lived, decisions taken now can have implications for decades into the future. But to avoid dangerous climate change, global emissions must peak within the next decade. Energy-policy decisions must therefore contribute to a rapid shift towards more sustainable, low-carbon energy systems,

rather than encouraging continued 'carbon lock-in'.

- Undertake risk-adjusted decision-making with regards to large investments. Deeper analysis of the policy-driven investment uncertainties will enable policymakers and industry executives to better understand the way forward.

Energy policymakers aiming to create stable, affordable, and environmentally sensitive energy systems struggle with three central dilemmas: stability versus flexibility, markets versus planning, and urgency versus legitimacy.[73] These pose some difficult trade-offs:

- **Stability versus flexibility.** Most energy-related investment, both large- and small-scale, will continue to come from private sources. Private investment requires a stable policy framework: companies will not risk their money if they cannot make reasonable predictions of financial outcomes. On the other hand, more policy experimentation is needed, and policy learning is critical. When policies do not work, they need to be revised, but this may act as a disincentive to investment.

- **Markets versus planning.** This is in some ways a false dichotomy, because markets are never 'free' (although they may be competitive), and governments and regulators set their rules. But the dichotomy is in important respects real. There is a strong desire on the part of many governments to try and set frameworks and let 'the market' deliver. More government intervention in markets and other activity will be needed if the urgency of climate-change is to be properly acknowledged and tackled. For some this raises the spectre of planning, the possibility of 'government failure' and over-centralisation. However it is difficult to see how the necessary speed of change can be reached without stronger governmental action.

- **Urgency versus legitimacy.** This is perhaps the most difficult tension of all. It is evident that time is short and that carbon emissions need to start falling consistently and substantially in the very near future. But the greater governmental intervention and radical policies needed to achieve this must, as a democratic and pragmatic imperative, be viewed as necessary among the broader public. They will only work if there is political support and a high degree of consensus.

None of these tensions can be easily resolved, and there will be enormous differences across countries in the ways these challenges are approached. Nevertheless, it is important that policymakers and experts recognise and start to confront these tensions, so as to begin the evolution towards more sustainable energy systems worldwide.

Notes

1. Transport accounted for 18% of global carbon emissions in 2009 and 13.5% of global GHG emissions.

2. GVSS - Global View Sustainability Services (April 2011) *Addressing The Rebound Effect.*

3. International Energy Agency (2010) *World Energy Outlook.*

4. International Energy Agency (2011) *World Energy Outlook*.

5. United Nations Environment Programme (2011) *Global Trends in Renewable Energy Investment 2011.*

6. BDEW - Bundesverband der Energie- und Wasserwirtschaft e.V. (May 2011) *Auswirkungen des Moratoriums auf die Stromwirtschaft*, Energie-Info.

7. GDP per capita on a purchasing power parity (PPP) basis.

8. International Energy Agency (October 2008) *Betwixt Petro-Dollars and Subsidies: Surging Energy Consumption in the Middle East and North Africa States*. Information paper.

9. Denotes regimes aligned with the former Soviet Union and those affected by the influence of the Soviet Union in the region.

10. World Economic Forum (April 2011) *Repowering Transport.*

11. United Nations Population Fund (2010) *State of World Population 2010.*

12. Levett, R. (2008) *Rebound and rational public policy-making.* Energy efficiency and sustainable consumption: the rebound effect. H. Herring and S. Sorrell.

13. International Energy Agency (2 May 2011) *Electric vehicles: are they a passing fad, or here to stay?*

14. World Economic Forum (April 2011).

15. http://www.london.gov.uk/priorities/transport/green-transport/electric-vehicles; and https://www.sourcelondon.net/; and http://www.dft.gov.uk/topics/sustainable/olev/plug-in-car-grant/

16. http://www.sfenvironment.org/downloads/library/sf_ev_summary.pdf

17. The Curitiba Planning and Research Institute, IPPUC, estimated the construction cost of the city's bus system at USD 3 million/km – as compared to the USD 8–12 million that would have been needed for a tram system. Friberg, L. (2000) *Innovative Solutions for Public Transport: Curitiba, Brazil*. Sustainable Development International, 3rd Edition. pp. 153–156. http://www.p2pays.org/ref/40/39732.pdf

18. World Energy Council (2010a) *Energy and Urban Innovation*

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23. Gilles Duranton, University of Toronto, Matthew A. Turner, University of Toronto (4 July 2010) *The Fundamental Law of Road Congestion: Evidence from US cities* (Draft).

24. Bedsworth, L.W. and Taylor, M.R. (2007) *Learning from California's Zero-Emission Vehicle Program.* CEP - California Economic Policy 3(4): 1-19.

25. Bedsworth, L.W. and Taylor, M.R. (2007) .

26. Goldemberg J, Coelho ST, Nastari PM, Lucon O. (2004) *Ethanol learning curved the Brazilian experience*. Biomass and Bioenergy 2004; 26:301–4.

27. World Economic Forum (April 2011).

28. S. Sorrel (2007) *The rebound effect: an assessment of the evidence for economy-wide energy savings from improved energy efficiency* (A review of 17 studies of rebound elasticity).

29. Cullen, J. M. and J. M. Allwood (2010) *The efficient use of energy: Tracing the global flow of energy from fuel to service* Energy Policy, 38(1): 75-81.

30. The Cabinet Office-HM Treasury, Stern, N. (2007) *The Economics of Climate Change: The Stern Review*; IPCC - Intergovernmental Panel on Climate Change (2008) *Mitigation of Climate Change* IPCC Fourth Assessment Report: Working Group III Report.

31. Note: ex ante estimates of what energy efficiency policies should achieve are significantly more common than rigorous ex-post evaluations of what they actually achieved - in part because it is methodologically challenging to estimate the 'energy savings' of a policy against a counterfactual baseline. This means that the level of confidence in the achievements of different policies is often much less than desired.

32. World Energy Council (2010b) *Energy Efficiency: A Recipe for Success.*

33. Horace Herring, Steve Sorrell, (2009) *Energy Efficiency and Sustainable Consumption – The Rebound Effect.*

34. Sorrell, S., J. Dimitropoulos, et al. (2009) *Empirical estimates of direct rebound effects*. Energy Policy 37(4): 1356-1371. 35. World Energy Council (2010)

36. International Energy Agency (2010) *Energy Performance Certification of Buildings, A Policy Tool to Improve Energy Efficiency.*

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44. World Energy Council (2010b)

45. World Energy Council (2010b)

46. Sorrell, S., C. Boemare, et al., (2003) *Interaction in EU Climate Policy - final report to DG Research*.

47. World Energy Council (2010b)

48. In order to avoid overlap with policies in the other two themes, financing mechanisms aimed at transport infrastructure or energy efficiency investment have not been considered under this theme.

49. International Energy Agency (May 2011) *Climate & Electricity Annual 2011: Data and Analyses.*

50. United Nations – Energy (2011) *Strengthening Public-Private Partnerships to Accelerate Global Electricity Technology Deployment: Recommendations from the Global Sustainable Electricity Partnership Survey.*

51. DoE, Department of Energy, Republic of South Africa. (2009) *Electrification status.* www.energy.gov.za/files/media/explained/statistics_electrification_2009.pdf

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54. The PJM area actually includes all or parts of 13 states and the District of Columbia, including Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia

55. Electricity generators are compensated for their available capacity by price-based or quantity-based payments. Price-based systems reward generators for their available capacity through lump sums (as applied in Spain, Argentina, Chile, Peru, and Colombia, and Korea, Repiblic) or 'uplifts' (previously applied in the UK pool system). These are in the form of an additional energy payment.

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58. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), REN21 (2009) *Renewables Global Status Report: 2009 Update*. Renewable Energy Policy Network for the 21st Century.

59. BMU, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. (June 2009) *Renewable Energy Sources in Figures: National and International Development*.

60. BMU, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (2009) *Electricity from Renewable Sources: what does it cost?*

61. The CDM enabled developed countries to exploit emission reduction potentials with lower marginal abatement costs in developing countries.

62. The CERs, are issued by the Executive Board of the CDM based on the demonstrated emissions reductions of each CDM project. They represent the rights of emissions originated by the CDM projects development. Each issued CER corresponds to 1 tonne of carbon dioxide equivalent emission cut or avoided thanks to the implementation of the CDM projects.

63. The UN executive organ which is mandated to govern the CDM system worldwide.

64. The DNAs are represented by ministries of governmental agencies.

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66. See CDM internet site: http://cdm.unfccc.int/Projects/projsearch.html.

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70. Carbon Trust (2010) *Catalysing investment in the low carbon economy*. Carbon Trust annual report - 2009/10.

71. Carbon Trust (2010).

72. Richard Rose (1991) *What is Lesson-Drawing?* Journal of Public Policy, 11, pp.3-30.

73. Scrase, I. and MacKerron, G. (2009) *Energy for the Future.*

74. Responses of WEC member committees do not represent the views of the respective governments

Appendix A. Project Participation

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World Energy Council Study Group

Joan MacNaughton, UK (Executive Chair)
Hajime Murata, Japan (Honorary Chair)

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World Energy Council Experts

Juan Pablo Gómez Lamarque, Argentina
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Eloy Alvarez, Spain
Maria Sunér-Fleming, Sweden

Research support (for the policy review)

University of Sussex (UK), Sussex Energy Group

Oliver Wyman Advisory Group

Michael Denton (Partner)
David Hoffman (Partner)
Boris Galonske (Partner)
Mike King (Senior Vice President, NERA)
Roland Rechtsteiner (Partner)
Alex Wittenberg (Partner)

Project Team

Christoph Frei (WEC, Secretary General)
Karl Rose (WEC, Director of Studies)
Joan MacNaughton (WEC, Executive Chair)
Hajime Murata (WEC, Honorary Chair)
Sandra Biesel (WEC, Senior Project Manager)
Mark Robson (Partner, Oliver Wyman)
Lucy Nottingham (Oliver Wyman)
Daniel Summons (Oliver Wyman)

Appendix B. Surveys

Survey of industry executives

A survey was distributed to approximately 1,900 senior energy-industry executives around the globe to obtain industry perspectives on the key themes of this year's report. A multiple-choice questionnaire asked the executives for their opinions on key issues of energy efficiency, energy and mobility, and innovative financing mechanisms. The objective was to understand the extent to which the opinions of senior energy-industry executives aligned with those of the WEC Member Committees, whose members had been asked nearly identical questions in a separate survey.

The questionnaire received a response rate of around 10%, with 181 energy executives responding either on-line or by hard copy. In total, 246 energy executives started the survey, and their responses were used when possible. A breakdown of the respondents' demographics shows that the survey reflected a wide range of energy businesses, company types and sizes, and company operating locations, as shown in Figure 24.

Figure 24
Breakdown of industry survey responses

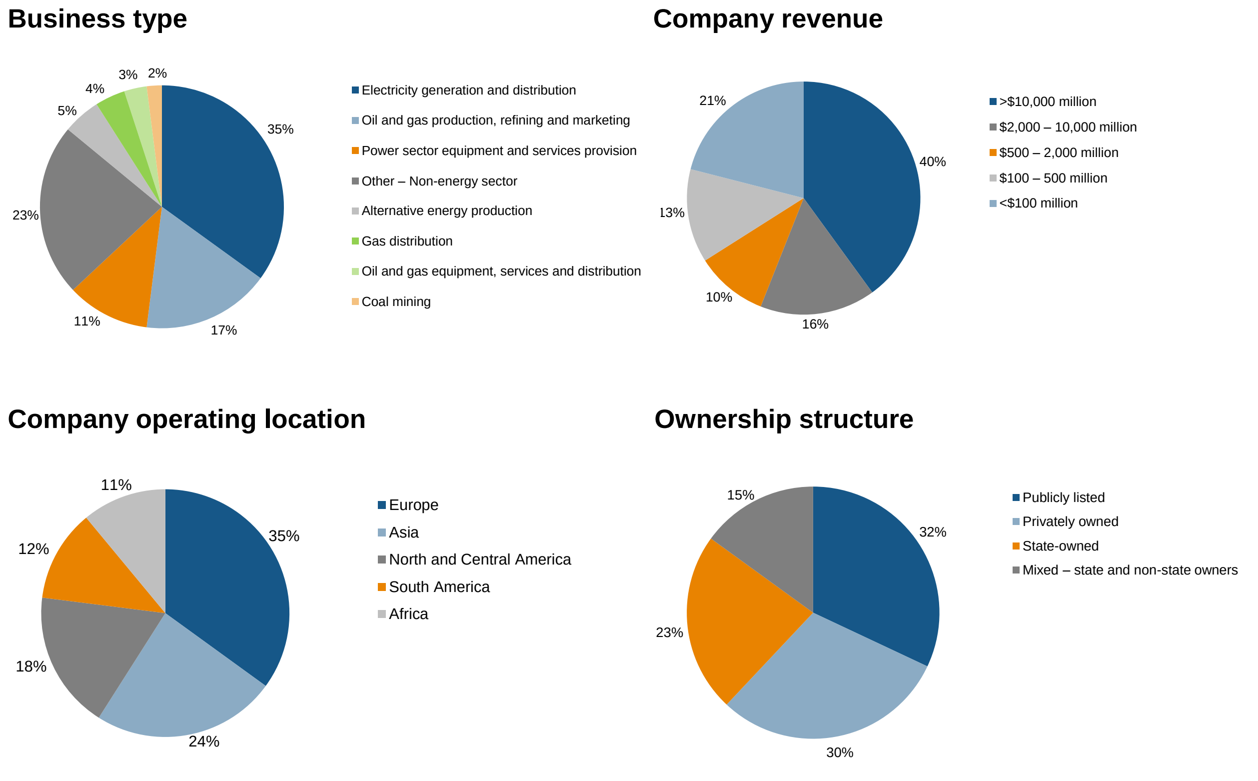

Figure 25
WEC member committees responding to the survey[74]

Argentina	India	Romania
Austria	Israel	Russia
Brazil	Italy	Serbia
Canada	Japan	Slovenia
China	Kazakhstan	South Africa
Colombia	Korea (Republic)	Spain
Congo (Democratic Republic)	Kuwait	Sri Lanka
Czech Republic	Latvia	Sweden
Denmark	Lithuania	Thailand
Estonia	Mexico	Trinidad and Tobago
Ethiopia	New Zealand	Tunisia
Finland	Nigeria	Turkey
France	Peru	United States of America
Germany	Poland	
Hong Kong, China	Portugal	

Survey of WEC member committees

The World Energy Council's member committees comprise an eclectic range of energy sector stakeholders in their respective countries. Each member committee was sent a slightly modified version of the industry survey, tailored for a country perspective on this year's report themes of energy efficiency, energy and mobility, and innovative financing mechanisms.

Forty-three WEC member committees responded, giving an overall response rate of around 46%. The countries that responded represent a broad and diverse group spanning economic status, natural resource endowment, political regimes, and geography. Those countries that responded can be seen in Figure 25

Appendix C. Policy review analysis

In order to identify relevant policy instruments for the analysis, the following criteria were used:

- The policy should be substantive in its ambition and impacts, and preferably high profile in terms of national and/or international attention.
- The policy should be perceived as having positive achievements in terms of environmental impact mitigation, security of supply, and/or social equity.
- The policy must have been established for some period and there must have been one or more ex post evaluations of its impact or a substantial amount of information available on the relevant policy.
- Each theme should include examples of different types of policy instruments (e.g., regulatory instruments such as obligations or standards, economic instruments such as taxes, information or voluntary measures, and public spending).
- The selection of policy instruments should include, as far as possible, policies from different regions, from countries with different levels of development, country sizes, and net energy importer/exporter data.

Based on a long list of possibilities, the set of 15 policies reviewed in the report were selected for detailed analysis.

The analysis mainly draws on the following sources: peer-reviewed academic articles, international policy/research bodies' reports, industry reports and government websites, and recent news reports in order to capture current developments and policy events. In addition, a number of experts from the respective countries and experts from countries with similar policies in place were interviewed. Quantitative estimates of economic, social, environmental, and other impacts were collected wherever possible, but in many cases the available evidence was limited and largely qualitative.

Appendix D. Index rationale and structure

Index overview

Country data was brought together in an Energy Sustainability Index. This provided a snapshot profile of WEC member countries in terms of both the three dimensions of energy sustainability and the broader political, social, and economic context. Indicators were selected that had a high degree of relevance to the research goals, exhibited low correlation, and could be derived from reputable sources to cover a high proportion of member countries. These sources included the International Energy Agency, the US Energy Information Administration, the World Bank, the International Monetary Fund, and the World Economic Forum.

The structure of the Index and the coverage of its 22 indicators are set out in Figure 2 (Chapter 1). The Index is weighted in favour of the energy performance axis by a factor of 3:1, with the scores for each dimension carrying equal weight within their axis.

The 2011 Index is a continuation of the 2010 Index, with the methodology and approach unchanged. Where possible, all data has been updated to reflect the release of updated datasets and the datasets used are unchanged. However, the indicators ‘macro-economic stability’ and ‘education’, which were provided by the World Economic Forum, have undergone a minor change due to an alteration in one of the underlying component datasets. This will introduce a measurable artificial modification in country positioning for year-on-year comparisons.

Full details of country scores by indicators and dimensions can be found on the WEC website at www.worldenergy.org/documents/index_2011.xls.

Figure 26 shows the ranking of countries against the energy performance dimensions of the Index.

Figure 26
Country rankings for the Index's energy performance dimensions

Source: Multiple (IEA, EIA, World Bank, WEF etc. 2009-2010)

Rank	Supply-demand balancing (2010 rank)	Social equity (2010 rank)	Enviornmental impact mitigation (2010 rank)
1	Canada (1)	United States (1)	Switzerland (1)
2	Russia (5)	China (2)	Nepal (3)
3	Côte d'Ivoire (34)	Japan (3)	Colombia (4)
4	Swaziland (32)	India (4)	Uruguay (11)
5	Denmark (3)	Germany (5)	Latvia (6)
6	Colombia (18)	Mexico (7)	Sweden (2)
7	Finland (4)	Indonesia (10)	Norway (5)
8	Ukraine (26)	France (9)	France (8)
9	Sweden (10)	Canada (6)	Albania (18)
10	Gabon (-)	United Kingdom (8)	Tanzania (9)
11	Croatia (73)	Brazil (13)	Brazil (7)
12	Argentina (24)	Italy (12)	Peru (10)
13	Germany (8)	Argentina (11)	Denmark (16)
14	Egypt (23)	Korea (Republic) (16)	Congo (Democratic Republic) (14)
15	Switzerland (2)	Spain (15)	Cameroon (15)
16	Japan (6)	Australia (14)	Ethiopia (42)
17	Cameroon (11)	Russia (18)	Sri Lanka (20)
18	Nigeria (17)	Turkey (17)	Austria (17)
19	Syria (Arab Republic) (35)	Poland (20)	Swaziland (12)
20	Hungary (25)	South Africa (19)	Portugal (22)
21	Norway (9)	Thailand (21)	Niger (19)
22	Latvia (60)	Colombia (23)	Finland (24)
23	Kenya (43)	Kazakhstan (33)	Ireland (23)
24	Tajikistan (41)	Iran (Islamic Republic) (25)	Kenya (26)
25	Bulgaria (42)	Ukraine (28)	Italy (25)
26	Albania (51)	Netherlands (26)	Croatia (36)
27	Spain (31)	United Arab Emirates (27)	Ghana (27)
28	Slovakia (15)	Belgium (29)	Luxembourg (31)
29	France (20)	Greece (24)	Philippines (29)
30	Congo (Democratic Republic) (56)	Romania (30)	Côte d'Ivoire (21)
31	Philippines (55)	Kuwait (32)	Spain (34)
32	United States (19)	Saudi Arabia (34)	Gabon (-)
33	New Zealand (16)	Switzerland (31)	New Zealand (30)
34	Kazakhstan (59)	Egypt (37)	Morocco (41)
35	Serbia (88)	Sweden (35)	Slovakia (40)
36	Lithuania (45)	Czech Republic (36)	Lithuania (32)
37	Austria (29)	Taiwan, China (22)	Paraguay (59)
38	Czech Republic (12)	Hong Kong, China (38)	United Kingdom (33)
39	Portugal (13)	Norway (39)	Japan (44)
40	Sri Lanka (63)	Pakistan (42)	Slovenia (37)
41	Slovenia (7)	Philippines (41)	Hungary (38)
42	Australia (38)	Bulgaria (40)	Senegal (46)
43	Macedonia (Republic) (37)	Serbia (43)	Germany (39)
44	Lebanon (66)	Austria (45)	Nigeria (45)
45	China (70)	Nigeria (48)	Tunisia (50)
46	Romania (33)	Israel (46)	Iceland (35)
47	Indonesia (28)	Lithuania (44)	Namibia (28)
48	Peru (68)	Slovenia (47)	Tajikistan (49)
49	Italy (46)	Algeria (49)	Argentina (52)
50	Uruguay (48)	Trinidad & Tobago (52)	Lebanon (58)
51	Mexico (44)	Morocco (58)	Turkey (43)
52	Israel (81)	Tunisia (51)	Romania (57)
53	Netherlands (14)	Latvia (50)	Greece (54)
54	Paraguay (40)	Qatar (60)	Mexico (55)
55	Iceland (52)	Cyprus (57)	Botswana (53)
56	Tanzania (64)	Hungary (54)	Canada (56)
57	Poland (30)	Syria (Arab Republic) (59)	Netherlands (60)
58	United Kingdom (22)	Peru (63)	Israel (69)
59	South Africa (47)	Portugal (55)	Belgium (51)
60	Tunisia (27)	Albania (64)	Pakistan (61)
61	Belgium (36)	Lebanon (53)	Russia (62)
62	Brazil (75)	Estonia (56)	Algeria (65)
63	Greece (50)	Macedonia (Republic) (62)	Jordan (73)
64	Pakistan (62)	Libya/GSPLAJ (65)	Indonesia (64)
65	Algeria (53)	Jordan (61)	Cyprus (66)
66	Hong Kong, China (79)	Finland (66)	Serbia (13)
67	Thailand (82)	Iceland (67)	Czech Republic (67)
68	Turkey (39)	Sri Lanka (69)	Macedonia (Republic) (63)
69	Estonia (54)	New Zealand (68)	Kazakhstan (74)
70	Libya/GSPLAJ (49)	Denmark (70)	Poland (71)
71	Iran (Islamic Republic) (21)	Slovakia (71)	Syria (Arab Republic) (72)
72	Mongolia (84)	Croatia (72)	Thailand (68)
73	Taiwan, China (67)	Ghana (74)	Egypt (47)
74	Niger (80)	Ireland (73)	Ukraine (70)
75	Namibia (83)	Cameroon (80)	United States (76)
76	Nepal (78)	Ethiopia (75)	Hong Kong, China (77)
77	Morocco (86)	Nepal (76)	Bulgaria (78)
78	Senegal (85)	Côte d'Ivoire (77)	Estonia (48)
79	Ghana (57)	Kenya (78)	Korea (Republic) (75)
80	United Arab Emirates (71)	Tajikistan (79)	India (80)
81	Luxembourg (77)	Tanzania (82)	Mongolia (81)
82	Jordan (87)	Mongolia (81)	Australia (82)
83	Korea (Republic) (61)	Paraguay (83)	Iran (Islamic Republic) (79)
84	India (58)	Senegal (84)	Qatar (87)
85	Saudi Arabia (69)	Uruguay (85)	Libya/GSPLAJ (83)
86	Trinidad & Tobago (76)	Botswana (88)	China (86)
87	Botswana (91)	Swaziland (87)	South Africa (84)
88	Ireland (65)	Niger (89)	Taiwan, China (90)
89	Ethiopia (89)	Luxembourg (91)	Trinidad & Tobago (89)
90	Cyprus (90)	Congo (Democratic Republic) (86)	Kuwait (85)
91	Qatar (72)	Gabon (-)	Saudi Arabia (88)
92	Kuwait (74)	Namibia (90)	United Arab Emirates (91)

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Brazil
Bulgaria
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Canada
Chad
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Colombia
Congo (Democratic Republic)
Côte d'Ivoire
Croatia
Cyprus
Czech Republic
Denmark
Egypt (Arab Republic)
Estonia
Ethiopia
Finland
France
Gabon
Germany
Ghana
Greece
Hong Kong, China
Hungary
Iceland
India
Indonesia
Iran (Islamic Republic)
Ireland
Israel
Italy
Japan
Jordan
Kazakhstan
Kenya
Korea (Republic)
Kuwait
Latvia
Lebanon
Libya/GSPLAJ
Lithuania
Luxembourg
Macedonia (Republic)
Mexico
Monaco
Mongolia
Morocco
Namibia
Nepal
Netherlands
New Zealand
Niger
Nigeria
Pakistan
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Uruguay

World Energy Council
Regency House 1-4 Warwick Street
London W1B 5LT United Kingdom
T (+44) 20 7734 5996
F (+44) 20 7734 5926
E info@worldenergy.org
www.worldenergy.org

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