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March 2009

Averting the next energy crisis: The demand challenge

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Preface

This report is the result of ongoing research collaboration between the McKinsey Global Institute (MGI) and McKinsey's global energy and materials (GEM) practice to understand the microeconomic underpinnings of global energy demand. In this report, we examine the outlook for energy demand across the range of end-use sectors and take a view on the trajectory of energy supply across fuel types.

Diana Farrell, former director of MGI, provided strong leadership on this project, as did colleagues from McKinsey's global energy and materials practice (GEM), notably Ivo Bozon, Pedro Haas, Occo Roelefson, and Matt Rogers. We also thank Jaana Remes, senior MGI fellow, for her consistent support and advice. Jaeson Rosenfeld led the project team for MGI with Koen Vermelfoort and Greg Terzian from the GEM practice. The project team included Wayne Hu, Sendil Palani, Utsav Sethi, and Anjan Sundaram from MGI; Marte Guldemond, Anniken Hoelsaeter, Prabhnoor Jolly, Cristian de Pace and Fonger Ypma from the GEM practice; and Rahul K. Gupta, Shobhit Awasthi, and Rahul Tapariya from McKc Analytics.

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This work is part of the fulfillment of MGI's mission to help global leaders understand the forces transforming the global economy, improve company performance, and work for better national and international policies. As with all MGI research, we would like to emphasize that this work is independent and has not been commissioned or sponsored in anyway by any business, government, or other institution.

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Executive summary

The world has been witnessing extraordinary volatility in energy prices in the past five years. Crude oil prices escalated as robust demand for energy, particularly from rapidly growing developing economies, combined with supply shock; even as crude hit record highs, economic growth and energy demand appeared to be immune. Then suddenly, everything changed. The credit squeeze and subsequent GDP slowdown have seen energy-demand growth slow down rapidly and prices drop sharply in response. Producers began to cut back on capital projects, and some companies struggled to find credit to drill attractive wells or build new power capacity.

Amid this high degree of uncertainty on both the demand and supply side of the energy equation, observers are keen to gain an understanding of how the supply-demand balance will evolve given the current global economic downturn. For how long is energy demand likely to contract? To what degree will today's credit constraints impact supply and for how long? How will the post-downturn balance between demand and supply play out—and with what effect on energy prices? This analysis by the McKinsey Global Institute (MGI) and McKinsey's global energy and materials (GEM) practice seeks to answer some of these questions.

Amid exceptionally high uncertainty about the future path of GDP in different regions during this turbulent period, we have looked at energy-demand growth projections using both mainstream current GDP projections and a range of alternative scenarios around these estimates.[1] The "moderate" case projects a global GDP downturn producing a total 4.7 percent gap to trend—felt mostly in 2008 and 2009—and then recovery in 2010. MGI's moderate case assumes that, under current consensus GDP projections, energy-demand growth will experience a short-term lull in 2009 due to the global economic downturn and the credit squeeze but is likely to rebound sharply thereafter across all fuel types. As demand recovers, CO_2 emissions will grow rapidly.[2]

However, we should note that consensus forecasts for global GDP from both Global Insight and the International Monetary Fund have been subject to downward revision month after month since mid-2008. For this reason, we have added to our analysis a "severe" and a "very severe" case to reflect the successive downgrading of growth forecasts. In the event that we find ourselves in a more severe scenario that sees a reduction in credit to the non-financial sector, our severe case produces a gap to trend of 6.7 percent while the gap in the very severe case is 10.8 percent. This very severe case depicts a downturn a full three points worse than

1 The GDP projections used in this report are a composite of projections from the *World Economic Outlook*, International Monetary Fund, November 14, 2008, and Global Insight GDP projections, December 5, 2008. Note that the 4.7 percent decline from trend is also very close to the IMF's *World Economic Outlook* in January 2008, which called for slower GDP growth than in its November release, which we used for our composite case. For our precrisis case, we use Global Insight, January 2008. For our severe and very severe cases, we reduced moderate-case growth equally across all regions.

2 For those interested in a detailed discussion of CO_2 abatement, please see *Pathways to a low-carbon economy*, Climate Change Special Initiative, McKinsey & Company, January 2009 (www.mckinsey.com).

any global downturn since World War II, and lasts into 2012. Using these three cases, we hope to cover a broad range of possibilities for the depth and length of the downturn. It should be noted that, as of our publication date, Global Insight's most recent GDP forecast would have been closest to our very severe case, while the IMF's most recent projection would have matched our severe case.

Looking toward recovery, it is notable that, in our moderate case, developing regions will account for more than 90 percent of global energy-demand growth to 2020, with demand growth most rapid in the Middle East. In stark contrast, growth of liquids demand—including petroleum products and biofuels—and oil demand more specifically will be at or below 2006 levels even by 2020, according to our moderate case. We project that the United States will actually cut its per capita energy demand to 2020, partly reflecting action to boost the economy's energy productivity—the level of output achieved from the energy consumed.

Globally, potential exists for liquids-demand growth to outpace that of supply, laying the groundwork for a possible new spike in oil and natural gas prices.[3] This is true in both the moderate-case scenario as well as in a low-GDP case—although the imbalance would appear at a later date in the severe case. Although the supply of coal and gas appears to be sufficient to prevent long-term price inflation for these fuels, growth in the supply of oil will slow markedly.

What should policy makers do to head off a renewed imbalance between oil supply and demand, and how can they do so at the lowest possible cost? Our research shows that there is significant potential to abate oil-demand growth at a reasonable cost. Many of the levers available offer positive returns to investors and the potential for carving out profitable positions in new markets. While policy has made some progress in abating energy demand—over and above the short-term impact of recessionary conditions—much remains to do.

ENERGY-DEMAND GROWTH WILL FLATTEN IN THE SHORT TERM

A number of factors are working in concert to bear down on energy-demand growth today. Demand is now reacting to the hangover of high energy prices in 2008; to significantly tighter credit conditions; and to what appears to be a relatively deep and entrenched slowdown in global GDP. The demand response is particularly marked in the case of petroleum, where demand is concentrated in some of the sectors hardest hit by the economic slowdown including automotive, industrials, trucks, and air transport.

GDP is the most important driver of energy-demand growth (Exhibit 1).[4] Our moderate case—which we have built using a composite of GDP projections by the International Monetary Fund and Global Insight in late 2008—envisages that 2008 and 2009 will see the economic trough with negative GDP growth in developed economies in aggregate. Developing economies will see a marked projected deceleration in GDP growth from 5.1 percent in 2008 to 3.9 percent in 2009.[5]

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3 Oil prices would rise globally, and natural gas prices would rise in regions where gas is tied to crude oil via power-sector switching or by pricing agreements such as the Japanese Crude Cocktail (JCC).

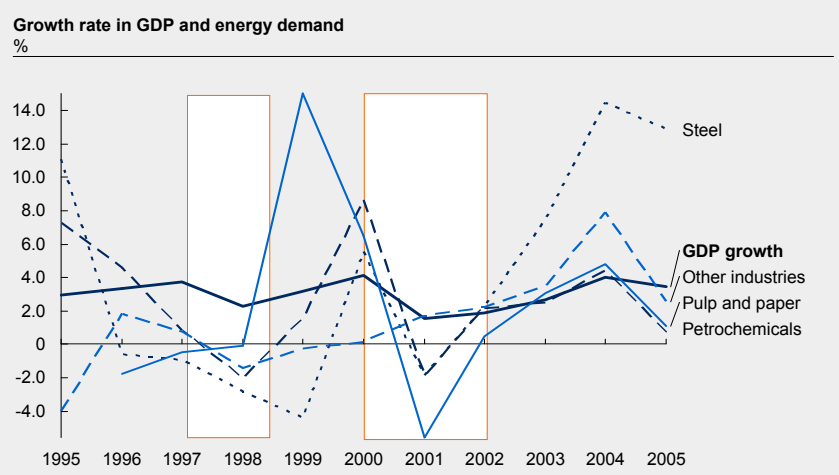
4 The other major drivers are energy prices and regulation.

5 *World Economic Outlook*, International Monetary Fund, November 14, 2008; Global Insight, December 5, 2008. Note that the 4.7 percent decline from trend is also very close to the projection in the *World Economic Outlook* released in January 2008, which projected slower GDP growth than the IMF's November *Outlook*, which we used for our composite case.

Global energy demand grew at a rate of 3.1 percent a year between 2002 and 2007, but we expect a marked deceleration in the pace of growth in 2007 to 2009 to a rate of only 1.0 percent per annum in our moderate case. In developed economies, energy demand will contract by 1.2 percent while energy-demand growth in developing countries will slow to between 1.5 and 2.2 percent. If a very severe global downturn unfolds, it is possible that global energy demand could contract instead of slowing (but still remaining positive) in our moderate case. Our severe case is based on a deeper, more prolonged reduction in credit to the nonfinancial private sector, with an additional 2 percentage point reduction in trend global GDP. In our severe case, demand for oil, coal, and gas is negative in 2007 to 2009. In our very severe case, demand stagnates for longer with oil demand only reaching 2007 levels by 2011.

Exhibit 1

Industrial energy demand has historically been procyclical, tracking GDP but with greater amplitude

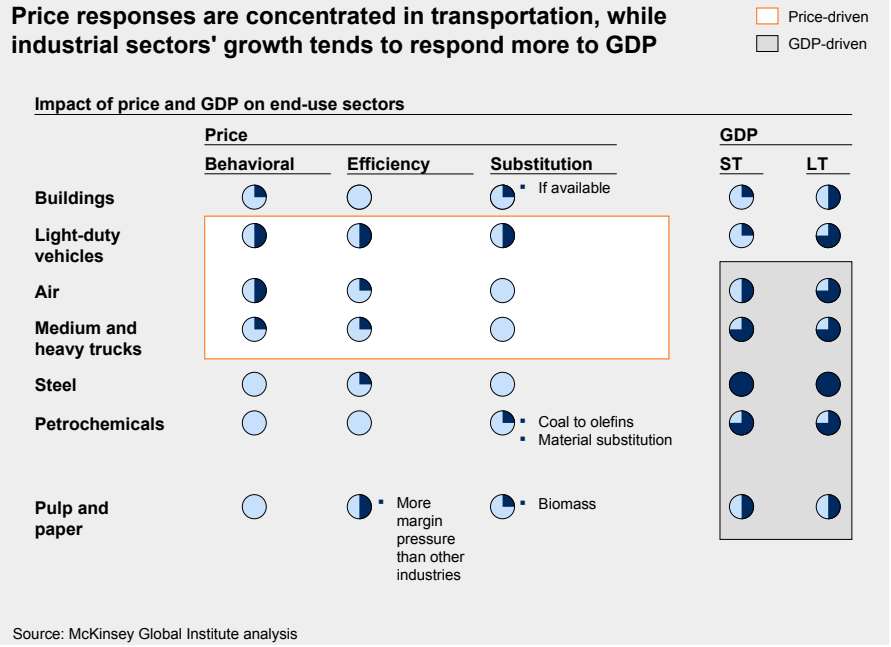


Source: IEA; Global Insight; McKinsey Global Institute analysis

Oil prices, too, have had a progressively negative impact on energy demand since 2004. Declines in oil demand have been mostly in developed economies while non-Organisation for Economic Co-operation and Development (OECD) energy-demand growth relative to GDP remained fairly robust up to 2007. Prices provoke the strongest short-term response in those sectors—light-duty vehicles (light vehicles) and air transportation—where fuel accounts for a high share of total costs and where taxes and other factors do not act as a significant cushion against market-price fluctuations (Exhibit 2). Developed countries show a stronger response because their demand is more concentrated in price-responsive sectors and because many non-OECD regions subsidize petroleum usage in the price-responsive sectors.

Exhibit 2

Price responses are concentrated in transportation, while industrial sectors' growth tends to respond more to GDP



Source: McKinsey Global Institute analysis

THE MEDIUM TO LONG TERM WILL SEE A STRONG REBOUND IN ENERGY-DEMAND GROWTH ACROSS FUELS

As the world economy recovers, so too will energy-demand growth, particularly for core fuels such as diesel, which has a high income and low price elasticity, and few available substitutes. As long as GDP growth returns to its long-term trend, we expect that energy-demand growth will also rebound. From 2010 to 2020, MGI's moderate case projects that energy-demand growth will recover to 2.3 percent per annum, nearly a full point faster than the period from 2006 to 2010, with global energy demand reaching approximately 622 quadrillion British thermal units (QBTU) in 2020.

Developing regions will account for more than 90 percent of global energy-demand growth to 2020. We project that the Middle East will have the fastest-growing energy demand of any major region, driven by the stepping up of industrial capacity building to take advantage of the Middle East's oil and gas supplies, as well as high, continuing growth in the region's vehicle stock, reflecting increasing wealth. Meanwhile, the Middle East will likely continue to see only limited efforts to improve energy efficiency. During the same period, our moderate case projects energy-demand growth in both China and India growing by 3.6 percent.

However, energy-demand growth will be virtually flat in the United States and Japan while Europe will see energy demand growing at a rate of some 1 percent, reflecting the inclusion in this region of many developing economies. In our moderate case, US liquids demand contracts marginally at a rate of 0.1 percent per annum and oil demand specifically by 0.4 percent a year to 2020, broadly in line with Energy Information Administration (EIA) projections. US demand for fossil fuels—natural gas, oil, and coal—will remain exactly flat to 2020. Of these three fuels, demand for only natural gas is projected to grow in the United States—at a rate of just 0.6 percent a year.

Breaking energy-demand growth down into different sectors, we see end-use demand increasing about equally in consumer- and industry-driven sectors. This reflects the increasing weight of developing countries, and it is in contrast to our

previous report in which we saw consumer-driven sectors accounting for close to 60 percent of long-term energy-demand growth, largely as a result of ongoing consumer demand in developed countries. The fastest-growing sectors will be steel, petrochemicals, and air transportation. Developing countries, including notably China and India, which are both investing heavily in long-distance transportation and infrastructure, will drive energy demand in these sectors. Efficiency improvements will have little impact on energy-demand growth of petrochemicals and air transport, in particular, as the opportunities to boost energy productivity have been largely captured and remaining opportunities are smaller in these sectors than in others.

Light vehicles will see one of the slowest rates of energy-demand growth. Although the vehicle stock will grow very strongly in China, India, and the Middle East, very rapid efficiency improvements across many other regions will help dampen demand from this sector in aggregate. Although we project an increased share of electric vehicles (EV) to 2020, there won't be a real impact on energy-demand growth until 2020 to 2030.

Five sectors within China—residential, commercial, steel, petrochemicals, and light vehicles—will account for more than 25 percent of overall energy-demand growth (Exhibit 3). Other sectors that make a large contribution to overall energy-demand growth are India's light vehicles, residential, and steel sectors, and the light vehicles and petrochemicals in the Middle East. In contrast, there are several sectors in different countries that will see energy demand contract, including the light-vehicles and pulp-and-paper sectors in developed economies, the former driven by efficiency regulations, as we have discussed, the latter by a shift from paper to digital media.

Exhibit 3

China grows demand strongly across several sectors, while developed-country growth is negative across several sectors

x>5 QBTU
5 QBTU >x>2 QBTU
2 QBTU > x > 0 QBTU
x< 0 QBTU

		Consumer					Industrial					
		Light-duty vehicles	Medium and heavy Trucks	Air transport	Residential	Commercial	Steel	Petrochemicals	Pulp and paper	Refining	Other industrial	Total
Developing	Rest of world	5.5	3.3	2.2	14.9	3.3	3.6	4.1	0.6	0.1	20.7	**58.3**
	Russia	0.8	0.2	0.3	0.7	0.9	-0.1	0.9	0.4	0.1	-0.3	**4.0**
	India	2.3	1.0	0.0	3.2	1.4	3.7	1.3	0.1	0.4	1.1	**14.5**
	China	4.8	1.7	0.9	11.6	5.5	9.7	8.8	0.8	0.4	8.2	**52.4**
	Middle East	2.4	0.9	0.4	4.6	0.5	0.2	3.3	0.0	0.6	5.0	**17.9**
Developed	Japan	-0.5	-0.1	0.3	0.0	1.1	-0.5	0.0	-0.3	-0.1	0.5	**0.4**
	Northwest Europe	-0.5	0.4	0.9	1.7	0.8	-0.1	1.0	0.2	-0.5	1.4	**5.2**
	United States	-1.8	0.6	0.7	1.5	1.7	0.1	1.4	-0.8	-0.5	2.9	**5.7**
	Total	**11.8**	**8.2**	**5.6**	**38.1**	**15.3**	**16.7**	**20.8**	**1.0**	**0.5**	**39.5**	**158.5**
		80 QBTU					**79 QBTU**					

Source: McKinsey Global Institute Global Energy Demand Model 2009

The fuel mix will change only modestly to 2020 given the very large installed base of energy-using capital stock and relatively minor differences in growth rates among fuels. Coal continues to be the fastest-growing fuel (with China and India driving almost 100 percent of that growth) and oil the slowest-growing.

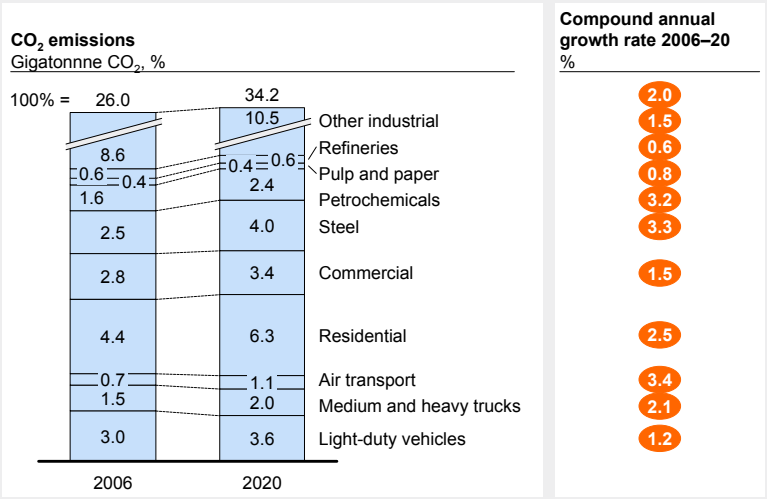
CO_2 emissions will grow marginally more slowly than energy demand

CO_2 emissions will grow slightly more slowly than energy demand as carbon-intensive coal use increases more quickly than that of other fuels but rapid growth

in renewables help to offset this (Exhibit 4). China's emissions will continue to grow at 3.7 percent per year, outpacing energy-demand growth of 3.5 percent per annum. CO_2-emissions growth will be flat or negative in developed regions due both to slow energy-demand growth and regulations that cause a shift to renewables and natural gas.

Exhibit 4

CO_2 emissions are projected to grow at 2.0 percent per annum



Source: McKinsey Global Institute Global Energy Demand Model 2009

The fastest-growing end-use sectors in terms of emissions are air transport, steel, and petrochemicals. In these sectors, CO_2 emissions largely grow in line with energy demand by end use. Light-vehicles emissions grow less quickly than energy demand due to the sector's increasing use of biofuels.

A RESUMPTION OF OIL PRICE INCREASES COULD DEVELOP AS REBOUNDING DEMAND OUTPACES GROWTH IN SUPPLY

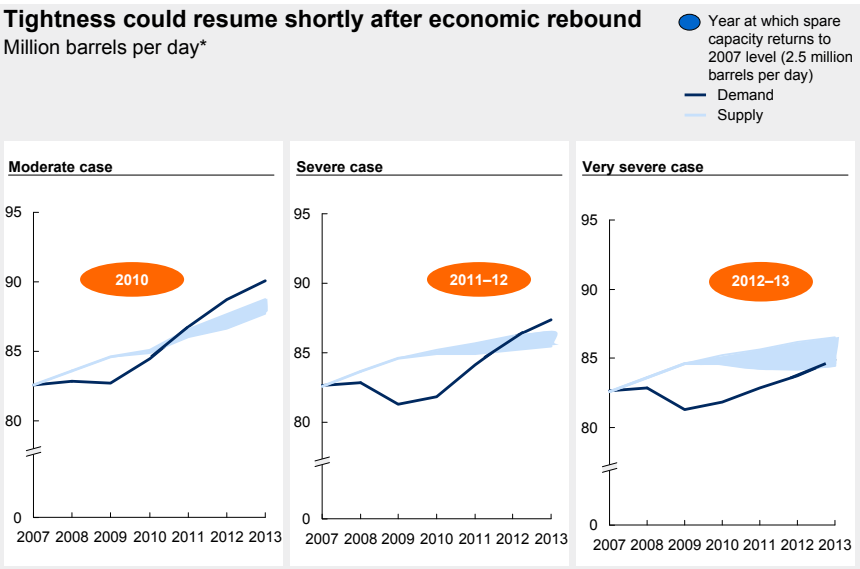
Without further action to abate energy-demand growth, spare capacity levels in the oil market could return to the low levels that we witnessed in 2007 as soon as 2010 to 2013, depending on the depth of the economic downturn.

The supplies of gas and coal do not appear to be a constraint to demand growth in most regions. Although temporary imbalances could exist between now and 2020, the overall long-term supply-demand path looks relatively balanced.

However, a different story could emerge in the oil market with the possibility of market tightness returning between 2010 and 2020 (Exhibit 5). McKinsey's GEM practice expects that oil supply will grow more slowly than oil demand at a $75 oil price (Exhibit 6). Therefore, a change in the oil price or policy, or a combination of the two, will be necessary to ensure that demand and supply are in balance. Many policy levers are available to achieve this rebalancing of supply and demand, including incentives to shift petroleum out of boiler-fuel applications, the removal of petroleum-product subsidies, and further incentives for higher fuel efficiency or EVs.

Exhibit 5

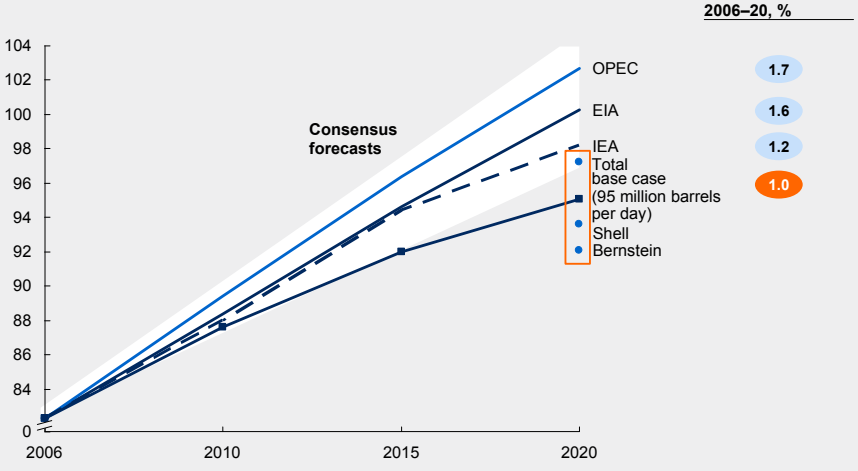
Tightness could resume shortly after economic rebound
Million barrels per day*



* Crude oil at the well head; includes biofuels and excludes refinery gains.
Source: McKinsey Global Institute Global Energy Demand Model 2009; McKinsey GEM practice

Exhibit 6

McKinsey's supply forecast is lower than those of the IEA, EIA, and OPEC
Liquids production* forecast, million barrels per day



* Includes crude oil, condensate, natural gas liquids, bitumen, ultraheavy oil, coal-to-liquids, gas-to-liquids, biofuels, and shale; does not include refinery processing gains.
Source: IEA; OPEC; EIA; Total; Shell; Bernstein; McKinsey Petroleum Supply Model

NEW POLICIES BOOSTING ENERGY PRODUCTIVITY ARE STARTING TO MITIGATE ENERGY-DEMAND GROWTH

Regulatory action to boost energy efficiency among various end users has begun to have a measurable impact on the trajectory of energy-demand growth. There has been evident progress in capturing available opportunities to boost energy productivity, although many more opportunities remain.

Our latest research projects that energy productivity will grow at 0.9 percent a year, at about the same rate as the 1.0 percent we projected in 2007. Energy productivity will rise across all regions with China leading the way. We project that the United States will actually cut its per capita energy demand to 2020—the only region to do so—although the level will still remain 50 percent above the average level in the

European Union (EU). Further action to boost energy productivity could abate global energy demand by between 16 and 20 percent of the projected 2020 level, representing a cut in energy-demand growth to this point of almost two-thirds.

This opportunity is somewhat smaller than we estimated in our 2007 report, which projected that policies were available to abate demand by between 20 and 24 percent (around two-thirds of energy-demand growth to 2020). There are several reasons for this, but the most important is that policy makers have since put in place regulations that will capture an estimated 15 QBTU of the overall opportunity, notably action in the United States and the EU on fuel-efficiency standards in the light-vehicles sector and mandates to boost the share of renewables in the energy mix in several countries. Also, the shorter time to 2020 has negated some of the opportunities, because a small portion of the capital stock has turned over since the time of our last report. That said, the potential now is more substantial on a per annum basis—it could reduce demand growth from 2.1 percent per annum to 0.5 percent per annum. The shorter time period to 2020 (17 years in our last report and 14 years now) and the fact that a large percentage of the opportunity is in retrofits or capital stock that will still turn over by 2020 explains the greater impact on demand growth.[6]

POLICY MAKERS CAN DO MUCH MORE TO ABATE OIL DEMAND

Given the risks of a resumption of imbalance in the oil market, importing-country policy makers should take care to include action on the demand side in their thinking (Exhibit 7). While there is certainly scope to implement supply-side policies as well is to increase supply growth, this report focuses on sizing the available levers to abate demand. Addressing the issue of demand holds more promise for a coordinated response than supply given that oil demand is more concentrated than supply—Europe, the United States, and China represent 50 percent of demand in 2020, while the top three supply countries—Saudi Arabia, Russia, and the United States—together represent only one-third of supply. Rather than competing for supply, oil-importing countries might choose instead to coordinate demand policies such as fuel-efficiency standards and new technology investments to abate demand, or to use the strength of their coordinated demand policies as bargaining chips with oil-exporting countries when pursuing supply additions. It is important to note that oil serves a valuable role in being a relatively inexpensive transport fuel (and lower carbon compared to some alternatives such as coal).

There is significant value in reducing the likelihood of another oil-price peak, through a combination of boosting energy productivity and fuel substitution, while maintaining supply investment during the downturn and credit crunch. Both importing and exporting countries could benefit by coordinating demand- and supply-side policies. Many opportunities for low-cost or even positive internal rate of return (IRR) opportunities exist to abate oil demand through efficiency or substitution, assuming an oil price of $75 a barrel. Moreover, policy plays a critical role in determining future demand for oil, offering scope for some mutually beneficial long-term tradeoffs between demand policy and supply installation.

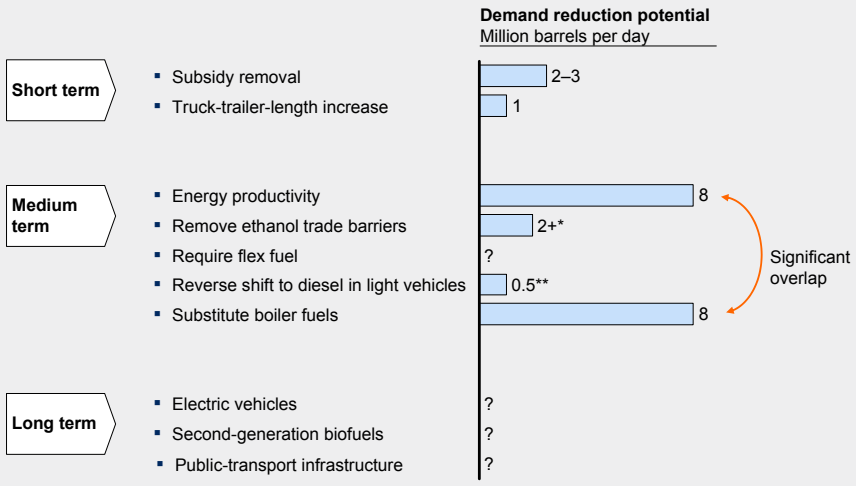
In the short term, there are a number of levers available to abate oil demand growth in a relatively cost-effective way. MGI research finds that policy makers could

6 Since this analysis was completed, a number of countries have announced large economic stimulus packages, some of which have a significant energy component. For instance, in the United States, some $106 billion, or nearly 14 percent, of the $787 billion stimulus package signed by President Barack Obama is earmarked for green-energy initiatives and includes tax breaks, loan guarantees, and incentives. In the EU, some $60 billion in stimulus packages will go to green measures, including more than $17 billion for energy efficiency and nearly $19 billion for clean cars.

achieve abatement of between 6 million and 11 million barrels per day by 2020, the amount required to keep demand and supply in balance. For instance, removing subsidies, largely in the Middle East, could reduce 2020 demand by 2 million to 3 million barrels per day in 2020. Increasing the size limit for trucks could save between 0.5 million and 1.0 million barrels per day.

Exhibit 7

Significant levers are available to abate oil demand



* Includes only increase in Brazilian ethanol; other countries could also grow production but are excluded from estimate.

** Only represents diesel demand abatement as switching to gasoline keeps overall petroleum products demand unchanged.

Source: McKinsey Global Institute analysis

In the medium term, an emphasis on shifting to fuels that are potentially more plentiful offers additional abatement potential. While the impact of such shifts will not be as rapid as the removal of subsidies or increasing truck size, the advantage is that these shifts do not depend on new technologies and most of them have IRRs potentially near or above 10 percent (depending on oil and diesel prices).

- Capturing energy productivity opportunities could abate 20 percent of 2020 demand across fuels but only 10 percent in oil. In light vehicles, there is potential to abate an additional 2 million barrels per day of demand by implementing stricter vehicle efficiency across economies. Action to boost energy productivity in industry and buildings offer the potential to abate an additional 6 million barrels per day.

- Removing trade barriers to sugar-cane ethanol could help abate oil demand. Given that the EIA projects that the United States will fall short of biofuel mandates, this may be a viable measure to fill the gap.

- Requiring all vehicles to be flex-fuel (i.e., running on a blend of more than one fuel, often gasoline and ethanol) would achieve greater fleet flexibility at an estimated cost of less than $100 per unit.

- Reversing the shift to diesel in passenger vehicles could save 0.5 million barrels per day of diesel fuel, which could help should diesel shortages emerge.

- Substituting boiler fuels could abate up to 8 million barrels per day.

Another set of demand-abatement levers, based on technologies that are currently in the research phase or are nascent, will become available in the longer term. Continued investment in such technologies can further contribute to achieving

long-term balance between supply and demand in energy markets. The key areas for investment are to support research into EVs, biofuels, and public-transportation infrastructure, the latter particularly in developing countries that are even now building public-transportation capacity on a large scale.

* * *

It would be all too easy to respond with complacency to a short-term easing back of energy-demand growth. Once the global economy begins to recover, energy demand will bounce back too, imposing costs on consumers and businesses and on the climate in the form of CO_2 emissions. There is even potential for oil market demand to grow more quickly than supply, risking another oil market shock. In these circumstances, losing the momentum on action to rein back energy demand could turn out to be a high-risk strategy—particularly given early evidence that policy to boost the economy's energy productivity is already having an impact.