رؤية VISION 2030
المملكة العربية السعودية
KINGDOM OF SAUDI ARABIA

الملتقى السعودي للكهرباء
Saudi Electricity Forum
طاقة مستدامة لرؤية شاملة
Sastainable energy for Comprehensive Vision

# Saudi Electricity Forum

Under the Patronage of His Excellency

## Khalid Bin Abdul Aziz Al-Faleh

Minister of Energy, Industry and Mineral Resources

10 -12 October 2017

Riyadh – Al Faisaliah Hotel

www.saudielectricityforum.com

# Sustainability Achievement by Improving Energy System Efficiency

***Iain MacGill***

Associate Professor, School of Electrical Engineering and Telecommunications
Joint Director (Engineering), Centre for Energy and Environmental Markets

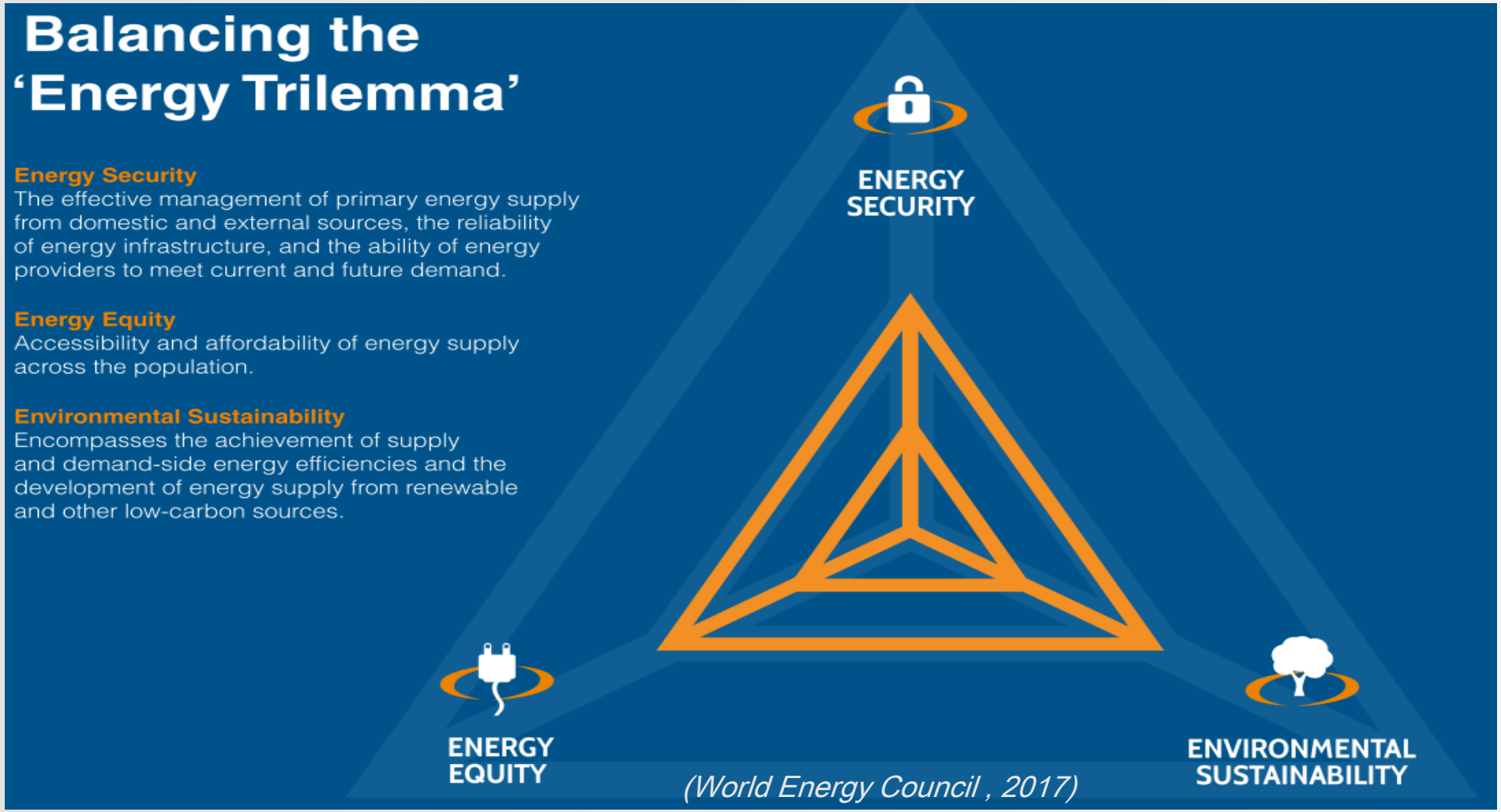
UNSW Sydney
Australia

Workshop - *Investment Prospects for Sustainable Energy and Comprehensive Development"*

Saudi Electricity Forum
Riyadh, Saudi Arabia

10-12 October 2017

# An agreed destination – what role might energy system efficiency play?




*(World Energy Council , 2017)*

# A framing challenge

- Energy systems typically only consider supply yet some of our greatest options lie on the demand side
- Efficiency
  - Is only a means to an end
  - has technical, economic, broader contexts
  - Has definitional challenges

- Energy efficiency
- Economic efficiency
  - *Productive*
  - *Allocative*
  - *Dynamic*

# Energy efficiency

Technical concept

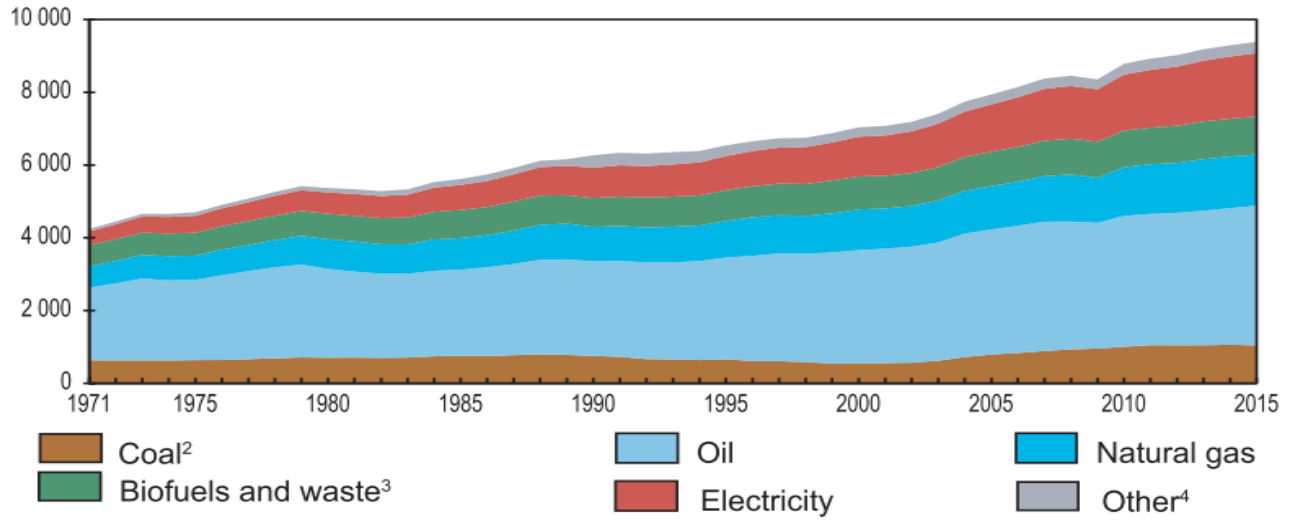
- Energy efficiency is the relative thrift or extravagance with which energy inputs are used to provide goods or services. Increases in energy efficiency take place when either energy inputs are reduced for a given level of service or there are increased or enhanced services for a given amount of energy inputs. (US EIA, 2002)

- Economic concept
  - Energy efficiency as cost-effective actions to reduce energy consumption
- Broader energy service related concept….

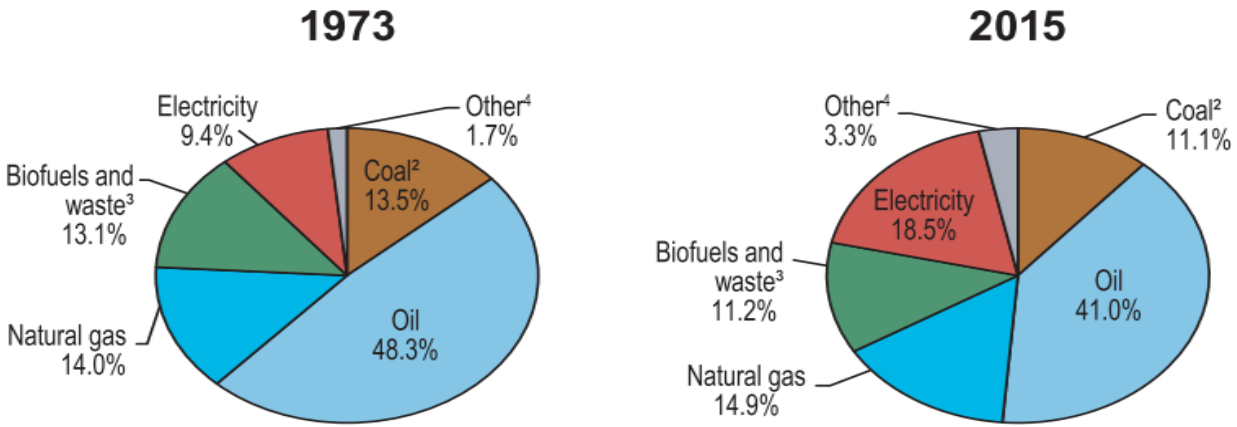
- EE measurement challenges
  - Bottom-up (technical) precise but incomplete – what of consumption?
  - Top-down (aggregate) intensity/productivity measures multiple factors– what contribution from EE
  - All technologies + processes **are** energy technologies + processes
    *=> EE is always relative to what would have happened otherwise*

# Both supply and demand challenges to address

World[1] TFC from 1971 to 2015 by fuel (Mtoe)




1973 and 2015 fuel shares of TFC

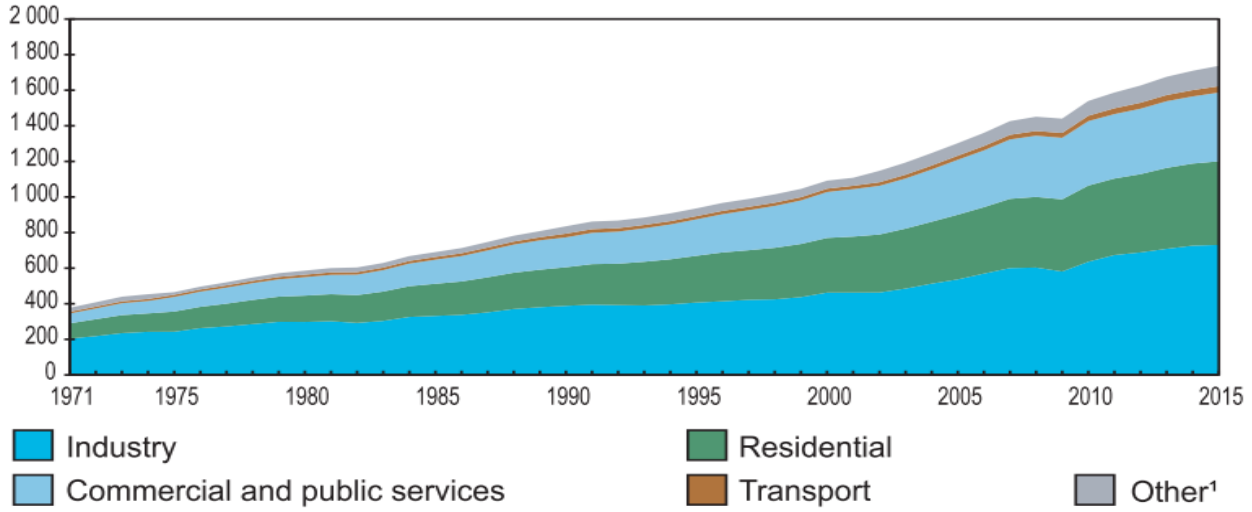



*(IEA, World Energy Statistics, 2017)*

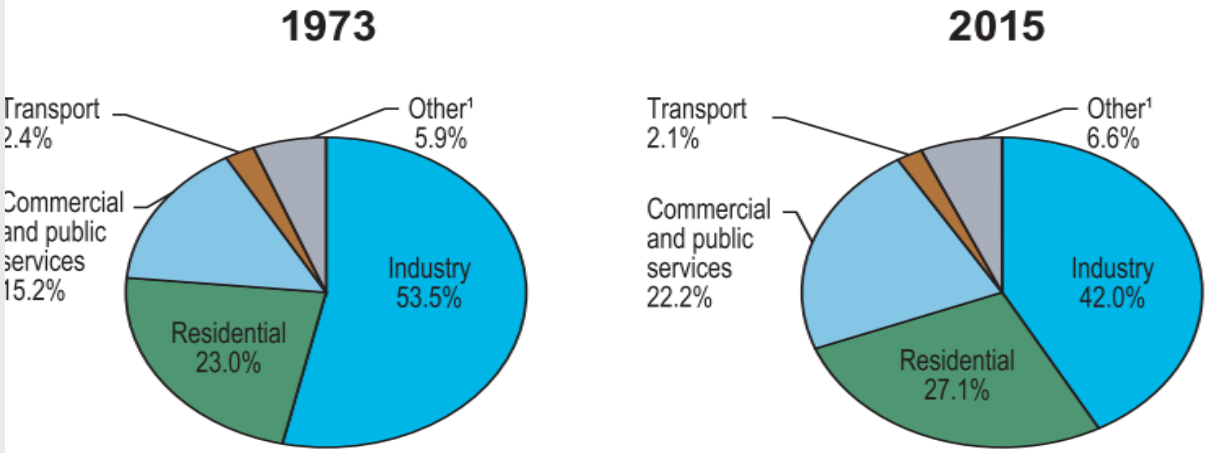
**4 661 Mtoe** **9 384 Mtoe**

# With the electricity sector, hence electricity users, having a key role

Electricity TFC from 1971 to 2015 by sector (Mtoe)




1973 and 2015 shares of world electricity consumption

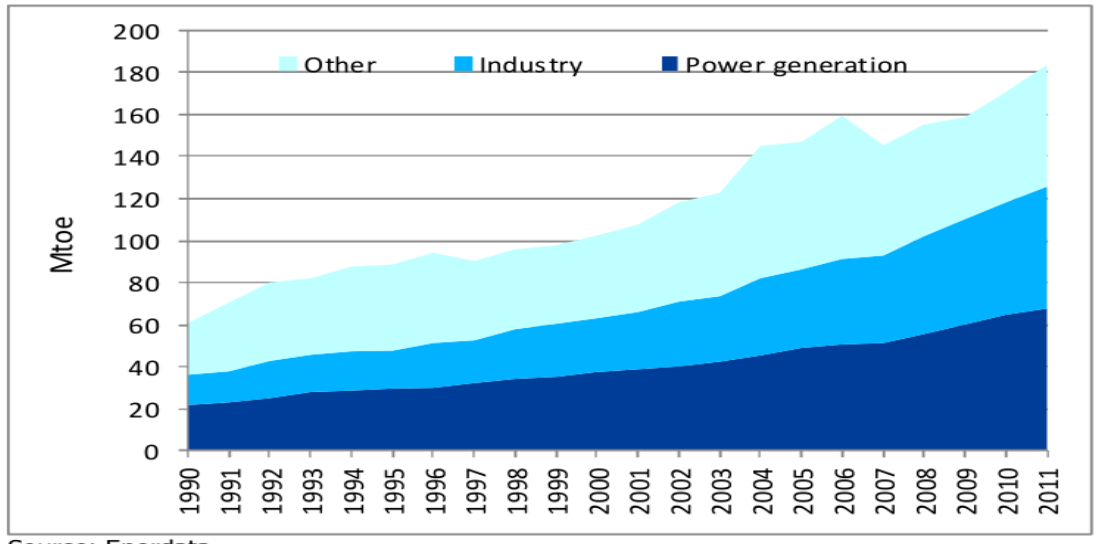



*(IEA, World Energy Statistics, 2017)*

**440 Mtoe** **1 737 Mtoe**

# Saudi Arabia's particular context

**Figure 1: Energy consumption trends by sector**




Source: Enerdata

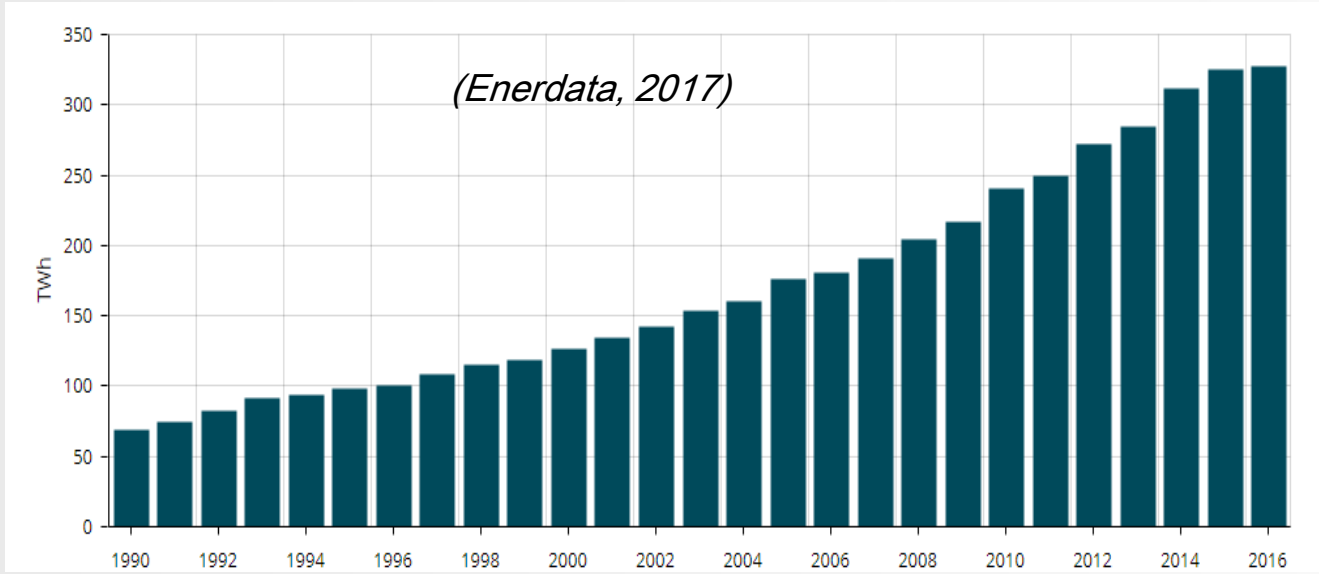
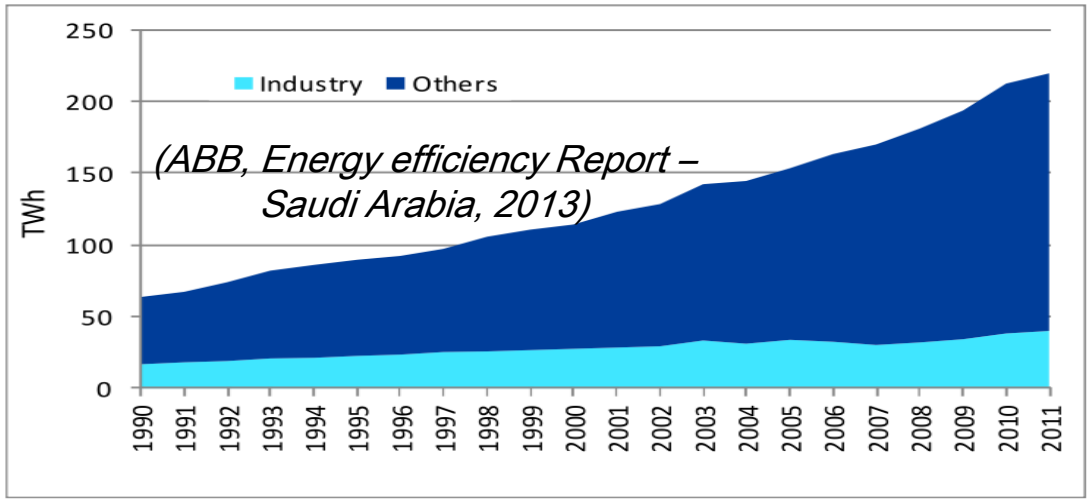
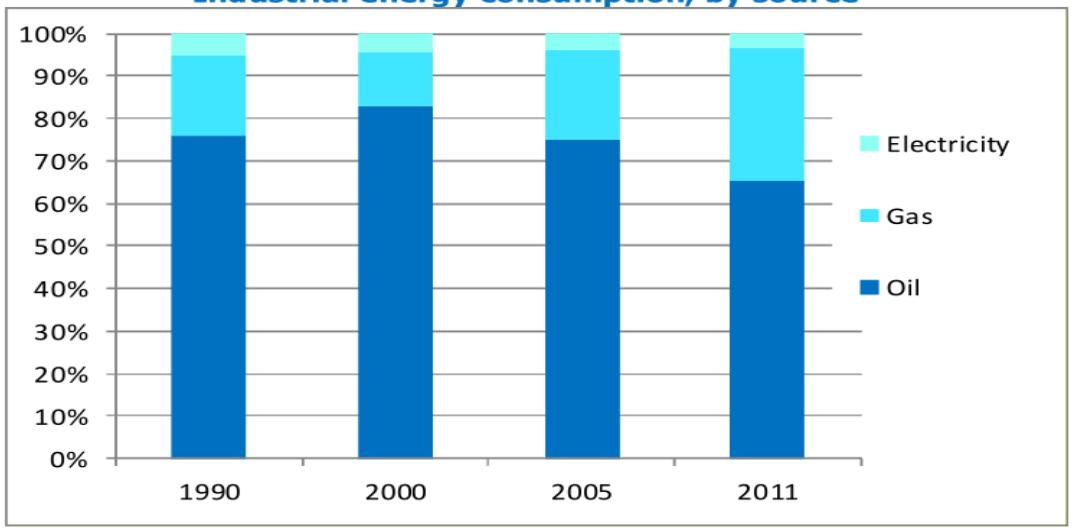



**Figure 2: Electricity consumption trends by sector**




Source: Enerdata

**Industrial energy consumption, by source***




* including non-energy uses

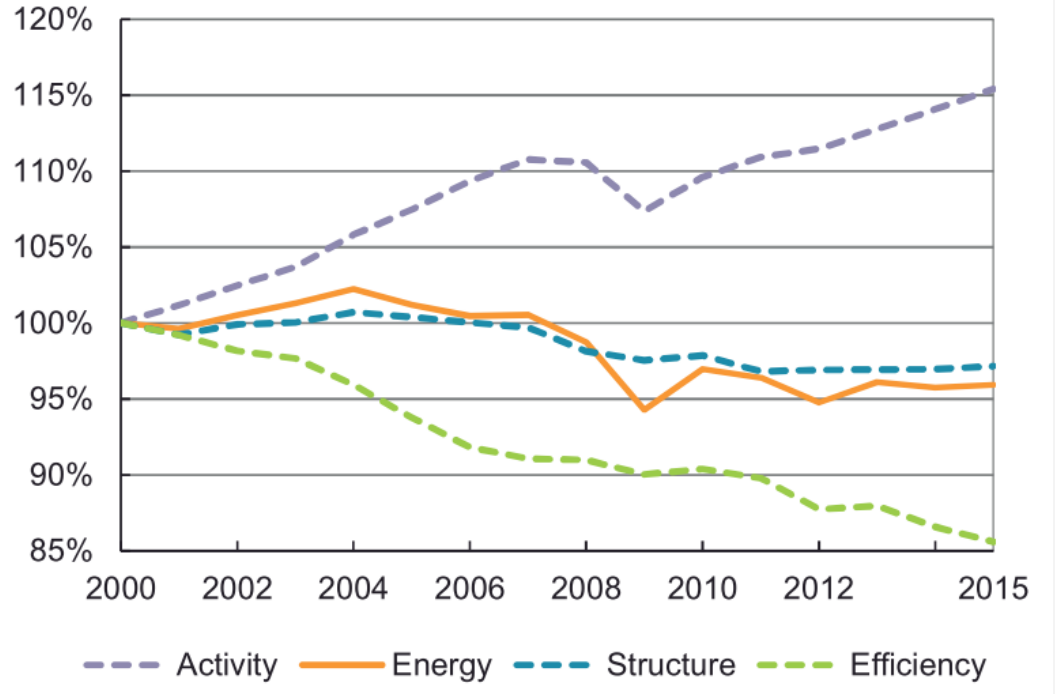
# Energy efficiency measurement

## Is energy intensity an energy efficiency indicator?

The energy intensity of a country is often used as an indicator of energy efficiency - the main reasons being that, at a high level, it is a proxy measurement for the energy required to satisfy energy services demanded[2], and the indicator is relatively easily available to evaluate and compare across countries. However, a country with a relatively low energy intensity does not necessarily have high energy efficiency. Equally, trends towards lower intensity are not necessarily driven by efficiency improvements. For

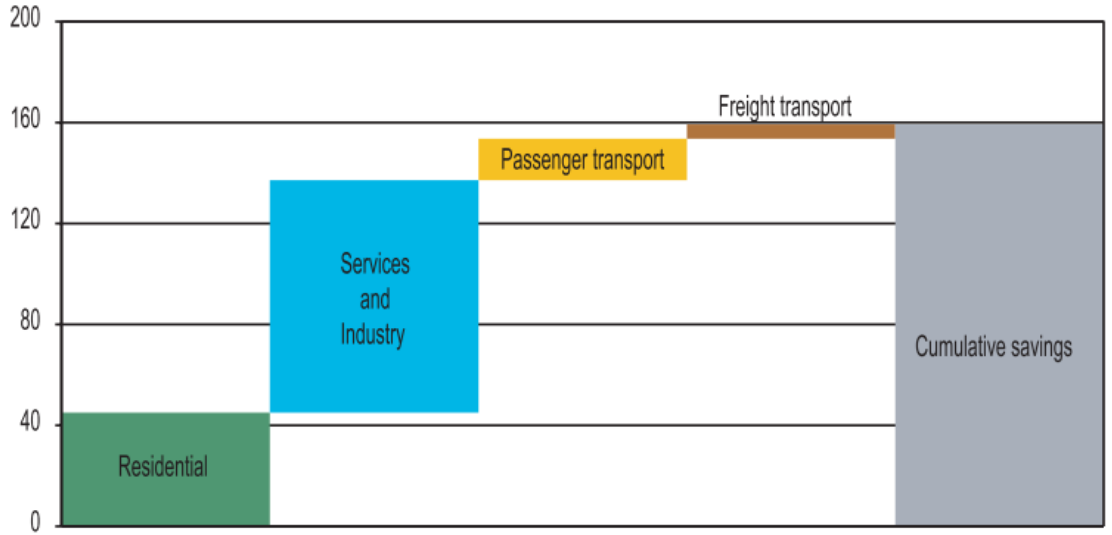
*(IEA, Energy Efficiency Indicators 2016)*

**Figure 15. Drivers of final energy consumption in IEA**



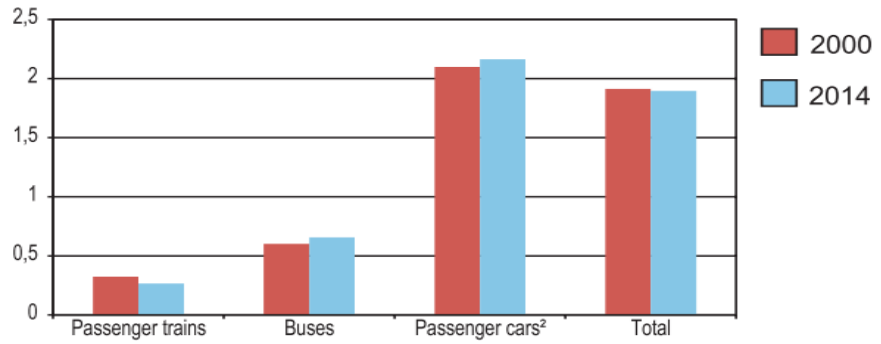
# Energy efficiency already the quiet achiever

## Estimated cumulative energy savings by sector in IEA, 2000-15 (EJ)

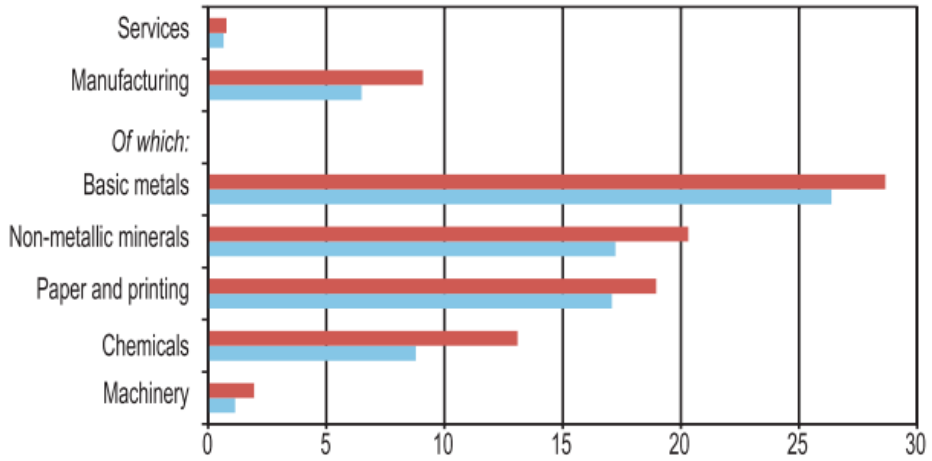



*(IEA, EE Market Report, 2016)*

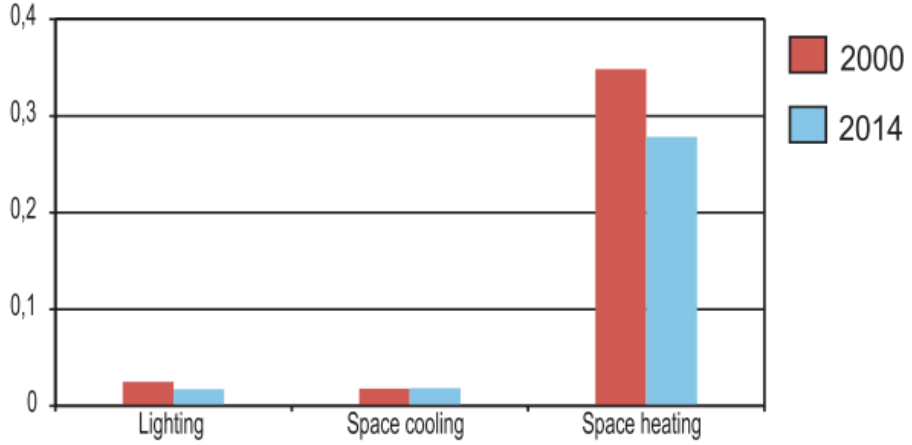
## Passenger transport in IEA[1]: energy per passenger-kilometre (MJ/pkm)




## Services and manufacturing in IEA[1]: energy per value added (MJ/2010 USD PPP)




## Residential in IEA[1]: energy per floor area (GJ/m[2])



# In both developed, emerging economies

**Figure 1.4** Growth in world energy service demand met through intensity improvements and new supply, 2015

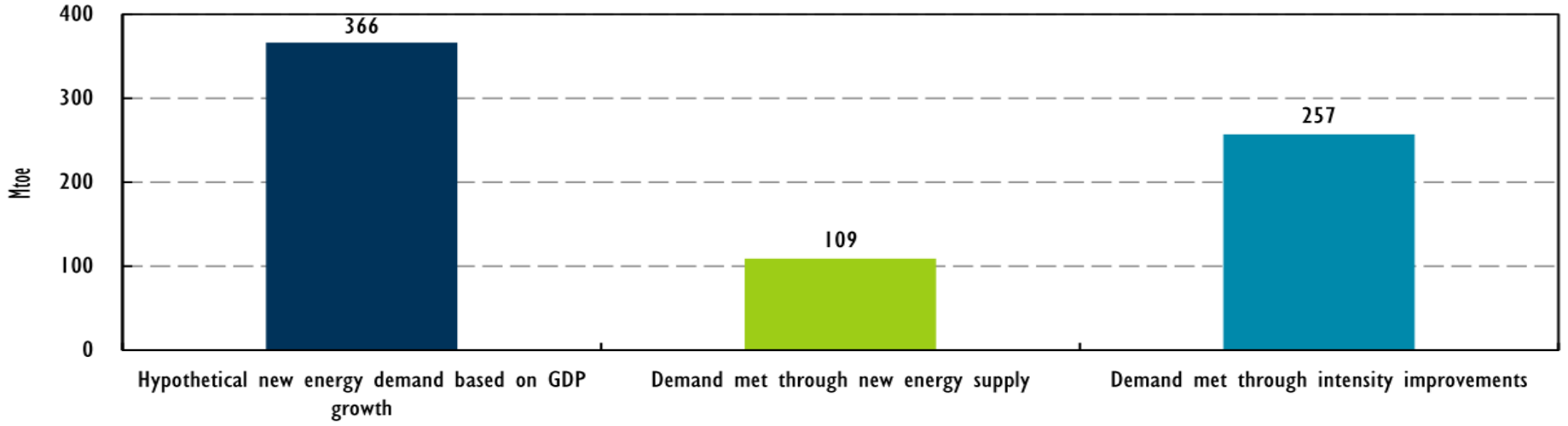



**Figure 1.1** Changes in energy intensity from

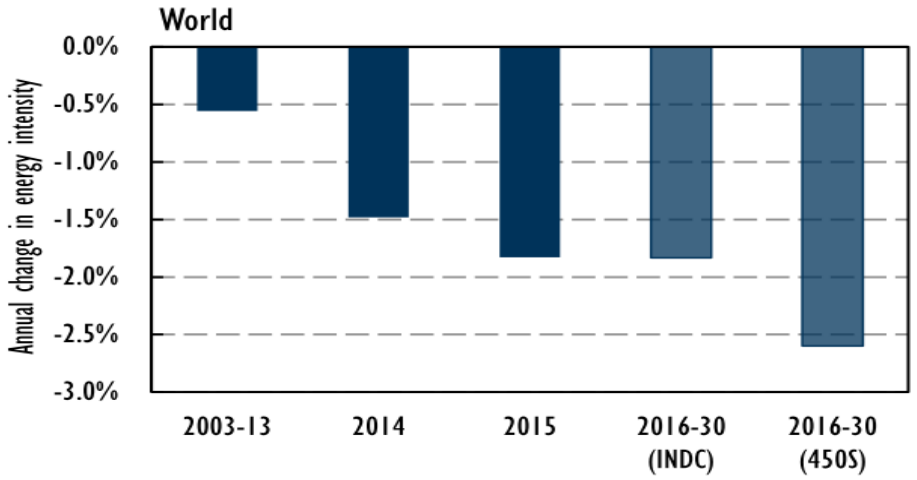
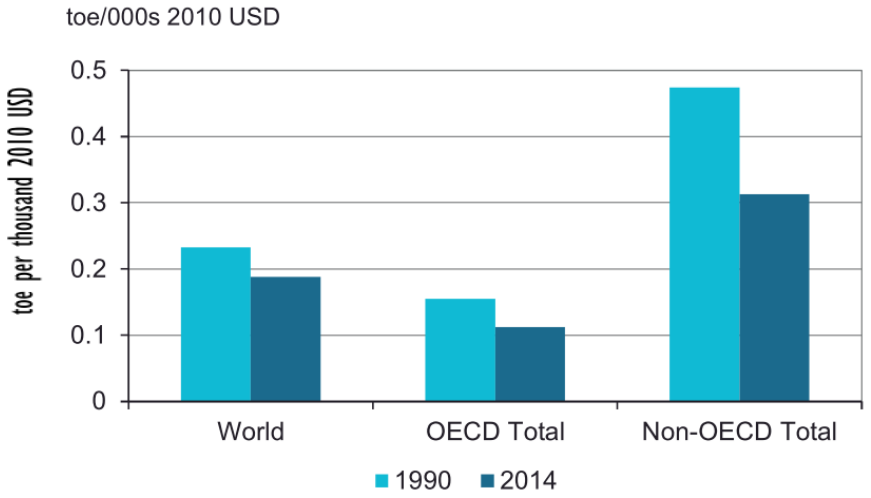
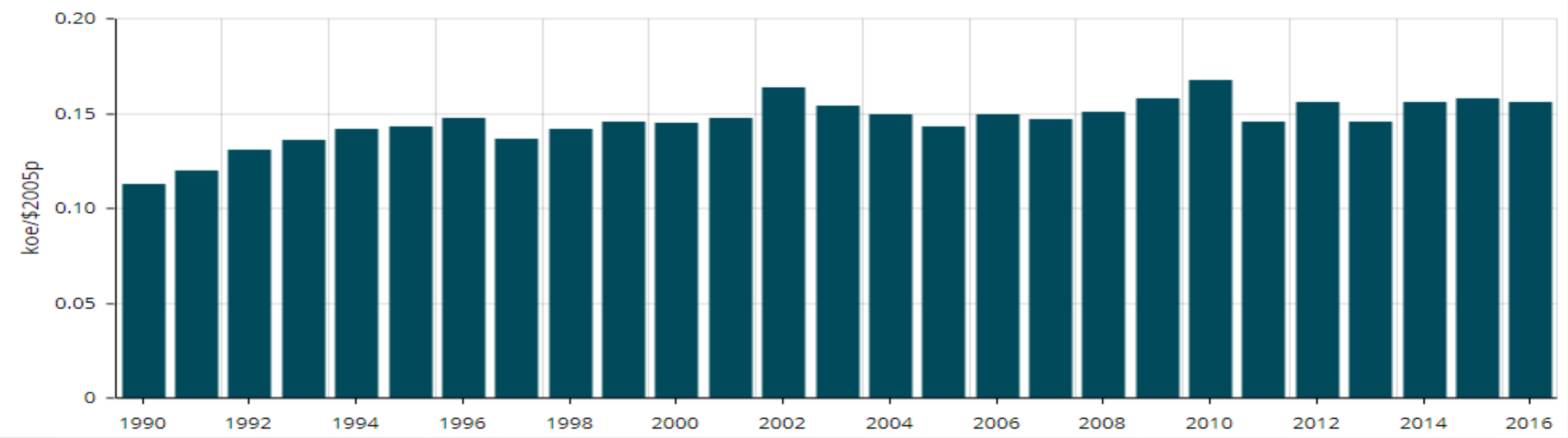



**Figure 3. Energy intensity 1990 and 2014**



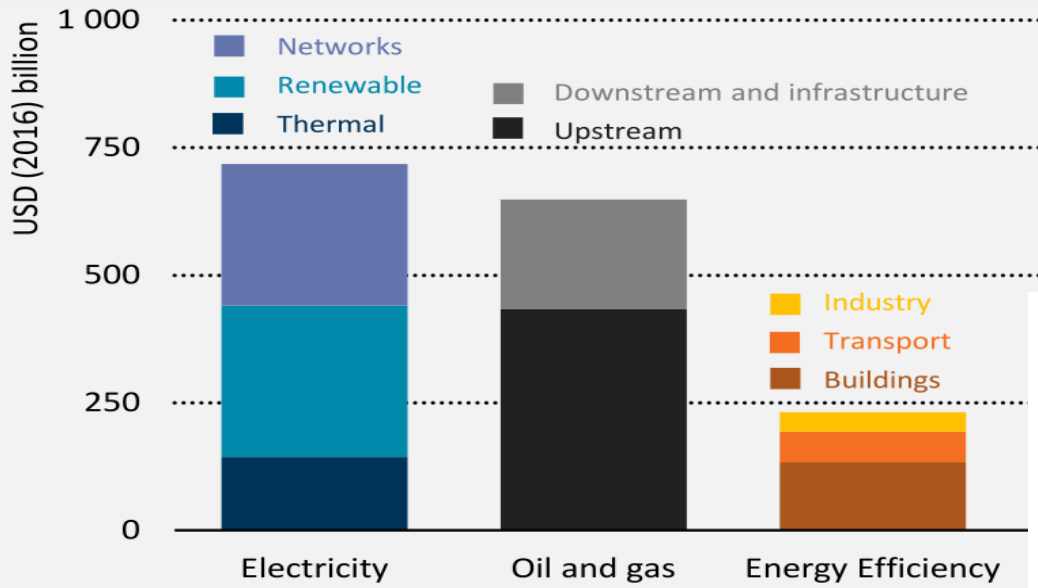
# Saudi energy intensity developments




*(Enerdata, 2017)*

# Energy efficient investment significant

**Figure 1.1 Global energy investment in 2016**

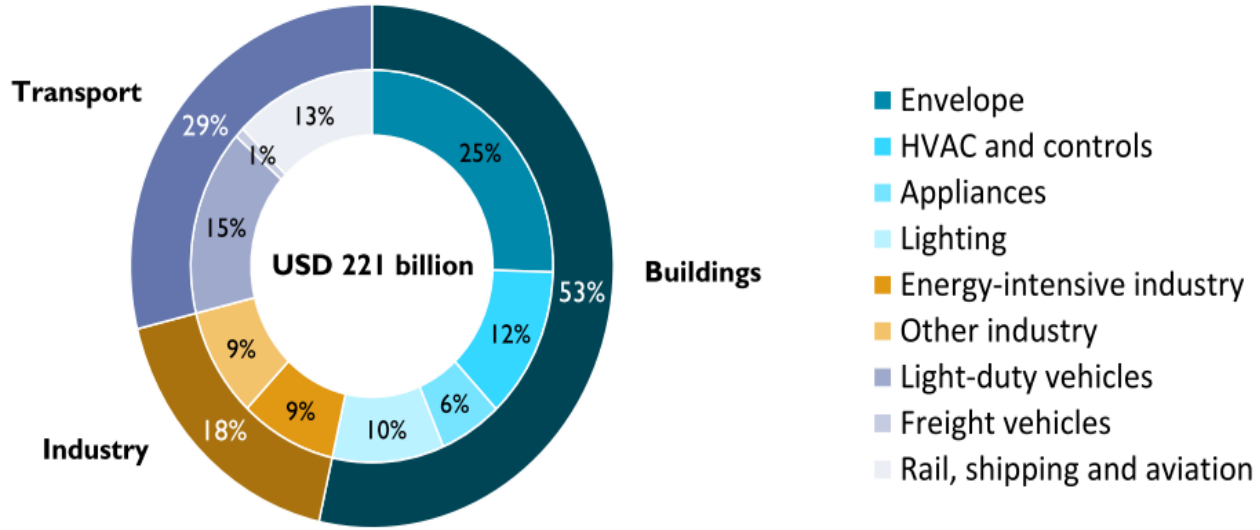



*(IEA, World Energy Investment, 2017)*

**Box 1.1 Measuring investment in energy efficiency**

As in *WEI 2016* and other recent IEA reports, we define an energy efficiency investment as the incremental spending on relatively efficient equipment or on building refurbishments that reduce energy use. The intention is to capture spending that leads to reduced energy consumption. Under conventional accounting, part of the spending would be categorised as

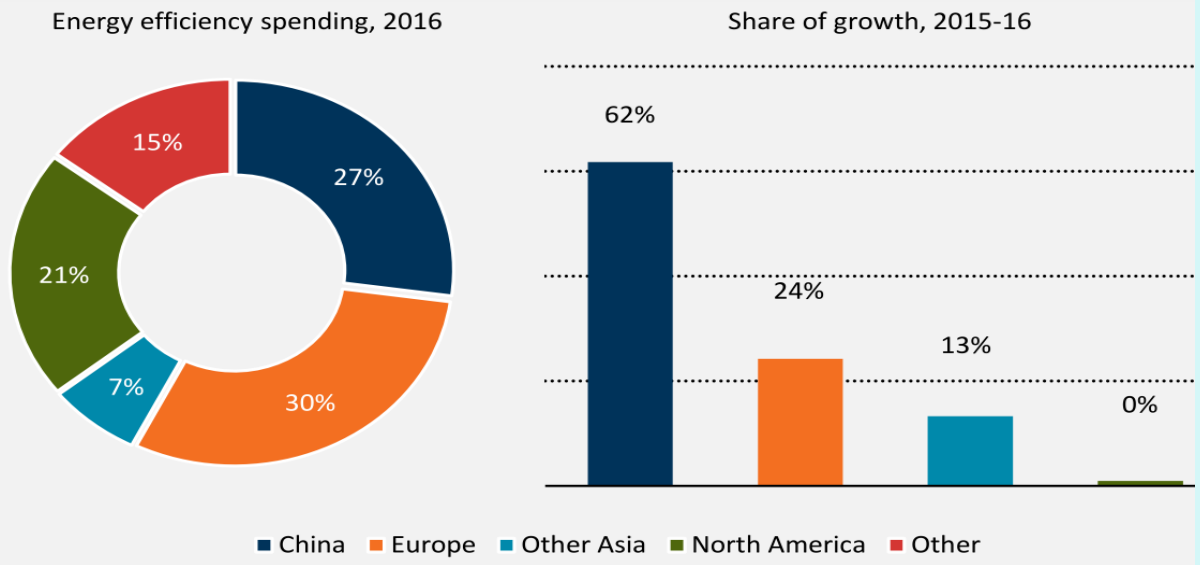
**Figure 5.1** Global incremental investment in energy efficiency by sector, 2015



# China showing the way

- **Progress in the People's Republic of China (hereafter "China") over the last decade has made it the world's energy efficiency heavyweight.** Between 2000 and 2015, its energy intensity improved by 30%, with energy efficiency gains playing a large role. Efficiency across China's major energy-consuming sectors improved by 19% – a faster rate than efficiency improvements in countries belonging to the International Energy Agency (IEA). Though China started from a relatively energy-intensive position (65% higher than IEA countries in 2000), the prioritisation of energy efficiency in government policy unlocked the significant improvement potential, particularly in the energy-intensive industry sector.
- **The annual energy savings from energy efficiency are equivalent to China's renewable energy supply.** Energy efficiency efforts since 2000 led, in 2014, to annual primary energy savings of 325 million tonnes of oil equivalent (Mtoe), equal to 11% of total primary energy supply (TPES). These savings are greater than the TPES of Germany in 2014.
- **China's energy efficiency gains avoided 1.2 gigatonnes of carbon dioxide ($GtCO_2$) emissions in 2014**. Overarching framework policies to improve energy efficiency in China, beginning in 2006 with the 11th Five Year Plan (FYP), have been one of the most important actions to reduce global greenhouse gas (GHG) emissions by any country over the past ten years.

**Figure 1.3 Energy efficiency investment by region and sector, 2016**




*(IEA, World Energy Investment, 2017)*

**Most of China's energy demand savings have been in industry.** Since 2006, a mandatory, target-based energy savings programme has been in place for the largest most energy-intensive enterprises. This programme was expanded to over 16 000 enterprises in 2011, and generated net annual savings of 216 Mtoe in 2014. The largest efficiency gains were in the cement, chemicals and the light manufacturing.

**The slowing growth of China's energy consumption, aided by efficiency, is rippling through global energy commodity markets.** Efficiency gains since 2000 led to annual savings of 350 million tonnes of coal. This was equivalent to 6% of global coal production and 29% of coal exports in 2014. As China is still 50% more energy intensive than IEA countries, energy markets will continue to be affected as China drives to improve intensity over the coming decades.

**China's efforts on energy efficiency are accelerating**. The 13th FYP (2016-20) targets a 15% energy intensity improvement from 2015 levels by 2020 and 560 Mtoe of energy savings annually by that year. Economic restructuring is planned to make up 65% of the targeted energy savings; energy efficiency and productivity improvements will deliver the balance. Restructuring to this scale will require focused, long-term policy leadership.

**As its economy continues to expand, China will need to continue to strengthen its commitment to energy efficiency to meet GHG emissions reduction in line with the global 2°C goal.** Between 2015 and 2030, energy intensity would need to improve at a rate of 4.7% per year, a step up over the average annual rate of improvement between 2004 and 2014 at 3.1%. Energy intensity improved by 5.6% in 2015, indicating that this transition is underway, if the rate of improvement remains at this order over the next 15 years.

# Energy efficiency has much more to offer

**Figure 3.16** Energy savings if all installed stock met higher standards, 2015

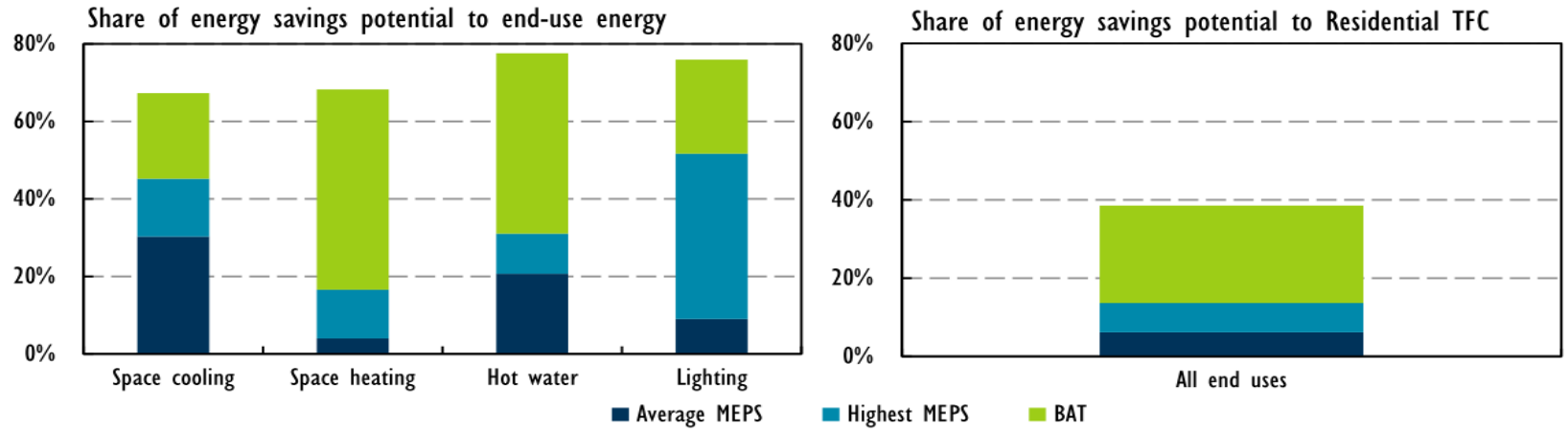
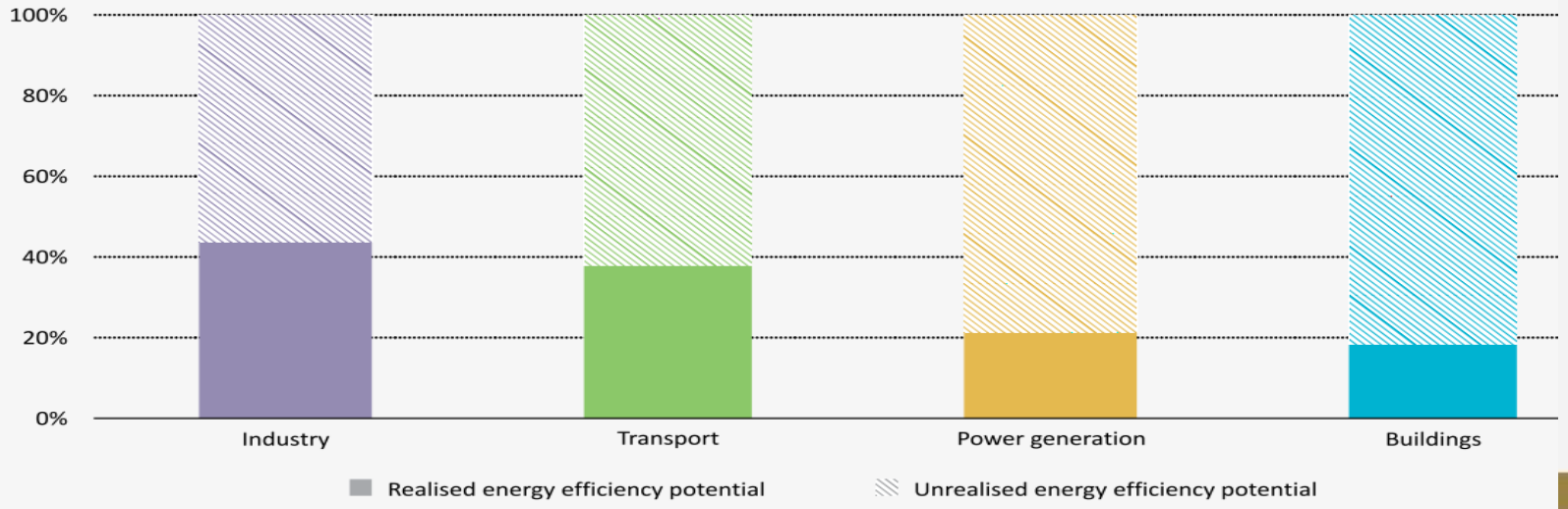



**Figure 1.3** Long-term energy efficiency economic potential by sector




Note: These energy efficiency potentials are based on the IEA New Policies Scenario outlined in IEA (2012c).

*(IEA, EE Market Report, 2016)*

# ..and seen as key to a low-carbon future

Figure 1.5. Final energy demand in the RTS and 2DS, 2014–60

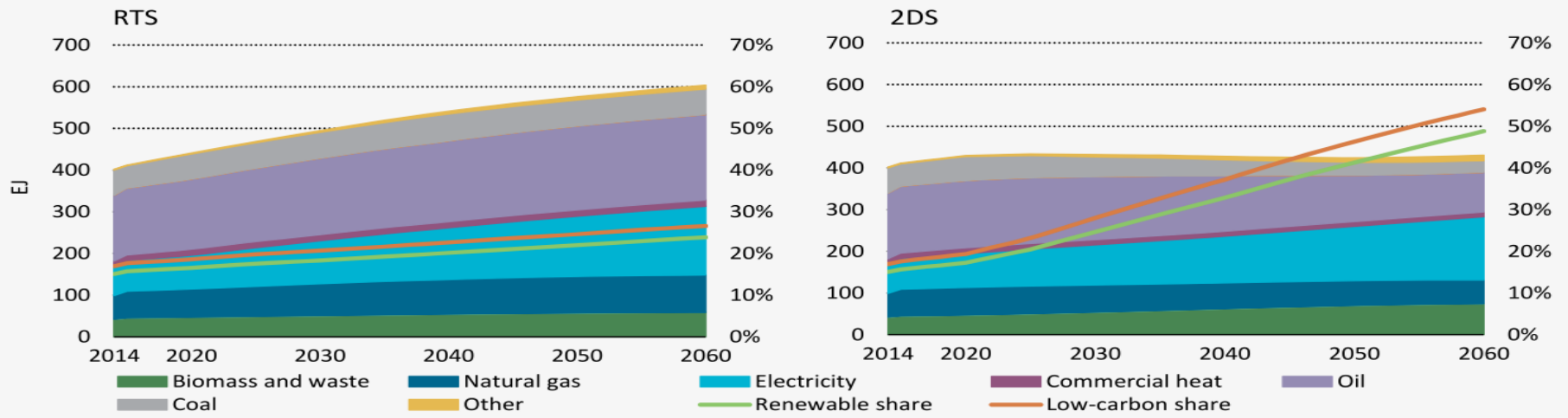
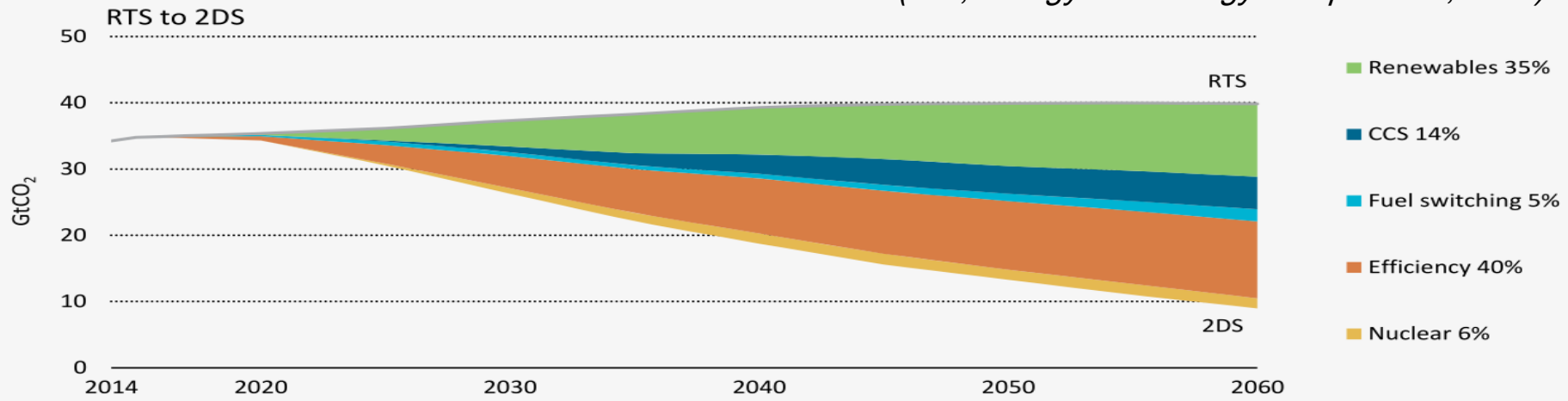
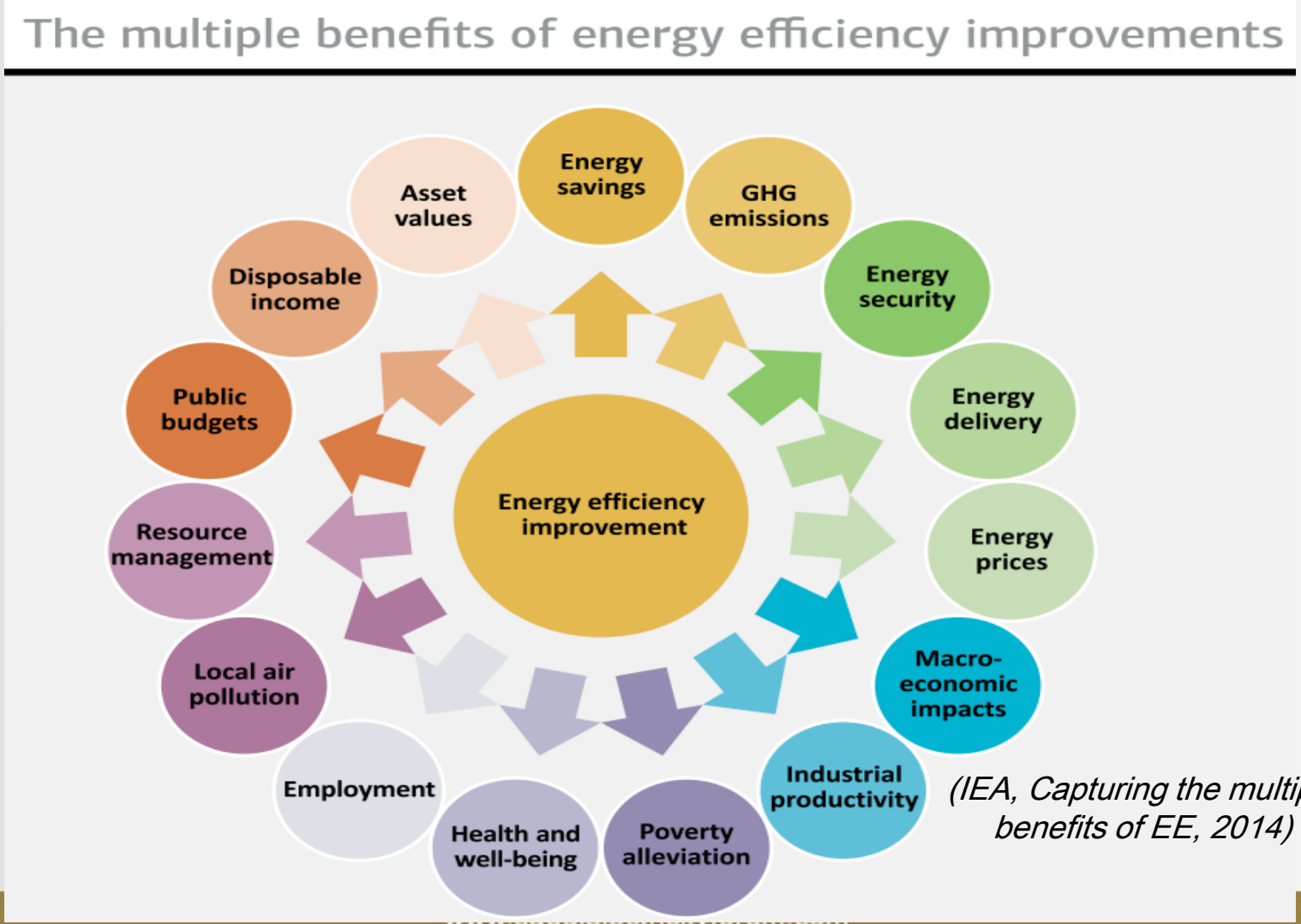



Figure 1.6. Global $CO_2$ emissions reductions by technology area: RTS to 2DS

*(IEA, Energy Technology Perspectives, 2017)*



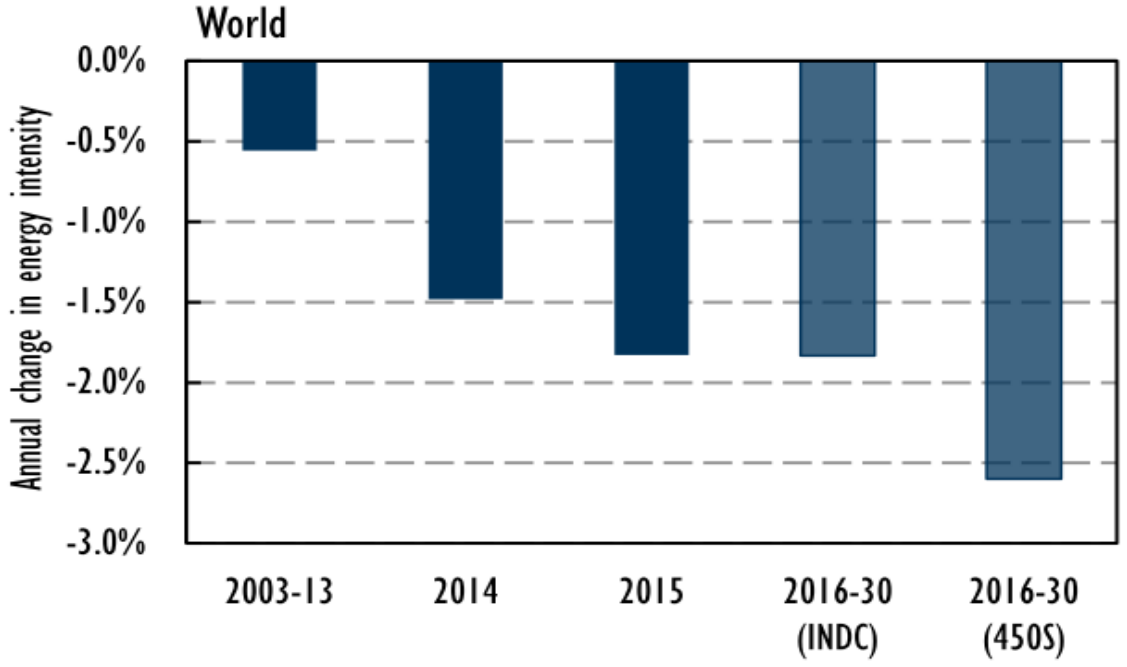
# Further reasons for energy efficiency action

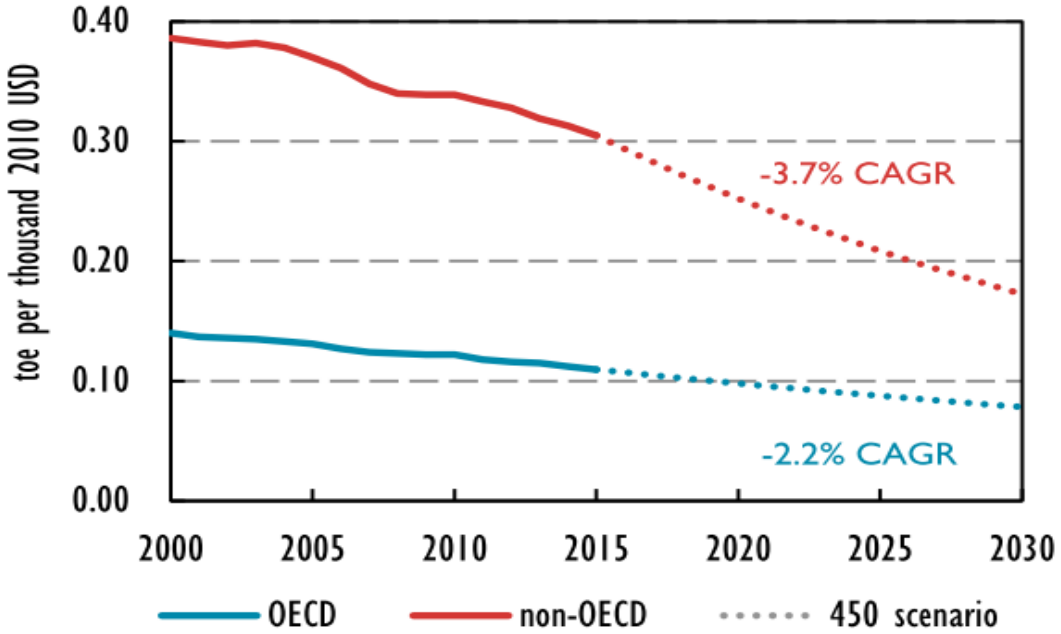



*(IEA, Capturing the multiple benefits of EE, 2014)*

# The scale of the challenge…

**Figure 1.1** Changes in energy intensity from 2003-30 by region and by scenario




*(IEA, EE Market Report, 2016)*

# Framework of Possible Policy Options…

## and their potential strengths, weaknesses

| POLICY LEVERS OPEN TO GOVERNMENT | | |
|---|---|---|
| PROS | | CONS |
| Can provide certainty and clarity where requirements and standards are set out in detail<br>Can be a cost effective way of achieving outcomes if well targeted | **LEGISLATION AND REGULATION**<br>Government mandating or using co-regulation or voluntary agreements to control certain activities | Can reduce overall levels of efficiency in the economy when resources are diverted away from areas where they could be used most productively<br>Imposes costs on the community when people are compelled to undertake actions that are not least cost.<br>May impose a significant burden on affected parties (such as high compliance costs)<br>Significant resources may be required to establish and maintain the regulatory framework<br>Can be more inflexible than other forms of intervention |
| Provides greater flexibility for participants in achieving compliance<br>Encourages economically efficient allocation of resources and least-cost methods of compliance<br>Avoids problems associated with centralised discretionary decision-making | **MARKET-BASED INSTRUMENTS**<br>Interventions that work by affecting prices in markets | Can be difficult to determine optimal caps or tax levels if sufficient information is not available<br>Does not work as well where:<br>• Solutions to a problem are similar across firms and households;<br>• There are site specific issues (e.g. air pollution hotspots)<br>Firms and households do not have experience with similar markets. |
| Disseminates information about compliance requirements<br>Can reduce resources expended on implementing and enforcing regulatory programs<br>Can educate the community about the virtues of a particular policy, increasing acceptance or compliance | **EDUCATION AND INFORMATION STRATEGIES**<br>Establishing education / information campaigns | May be less effective than other regulatory approaches as it relies on voluntary action<br>The community can become de-sensitised to or weary of messages for long term problems, reducing effectiveness<br>Specific groups may hard to target |
| Can be mobilised quickly and targeted in specific areas<br>Can demonstrate Government leadership and commitment to specific issues<br>Can drive private sector investment to deliver broader public benefits in multiple areas | **GOVERNMENT SPENDING**<br>Using Government funds directly or to promote or support certain activities or markets | Significant resources may be required to establish and maintain programs<br>Reduces resources available to spend on other areas |

(*Victorian Govt*, 2010)

# Standards and regulations

**Figure 3.5** Share of global TFC covered by mandatory energy efficiency standards and regulations by sector, 2000 and 2015

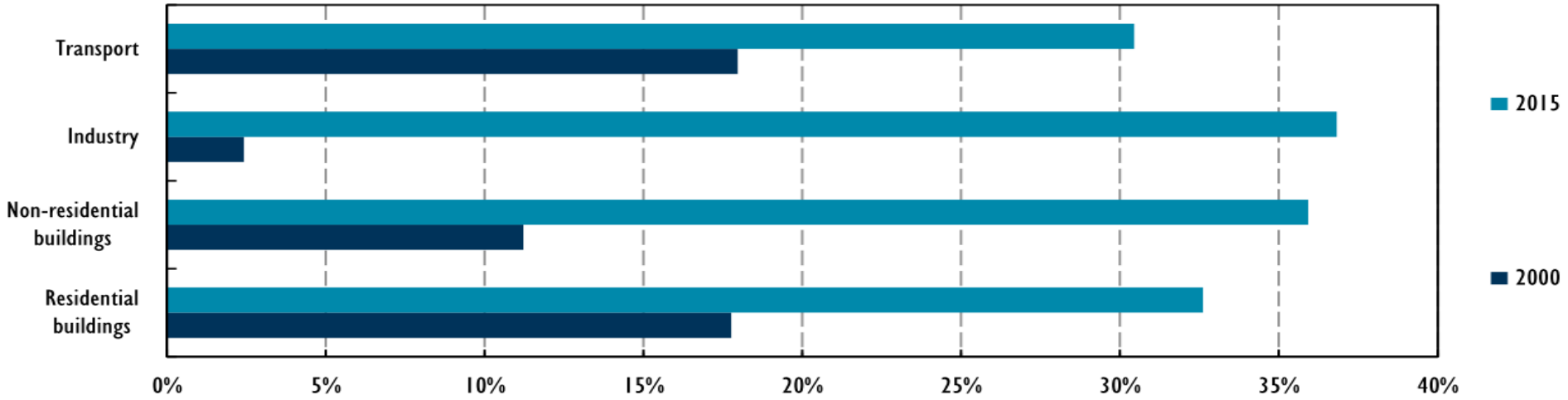
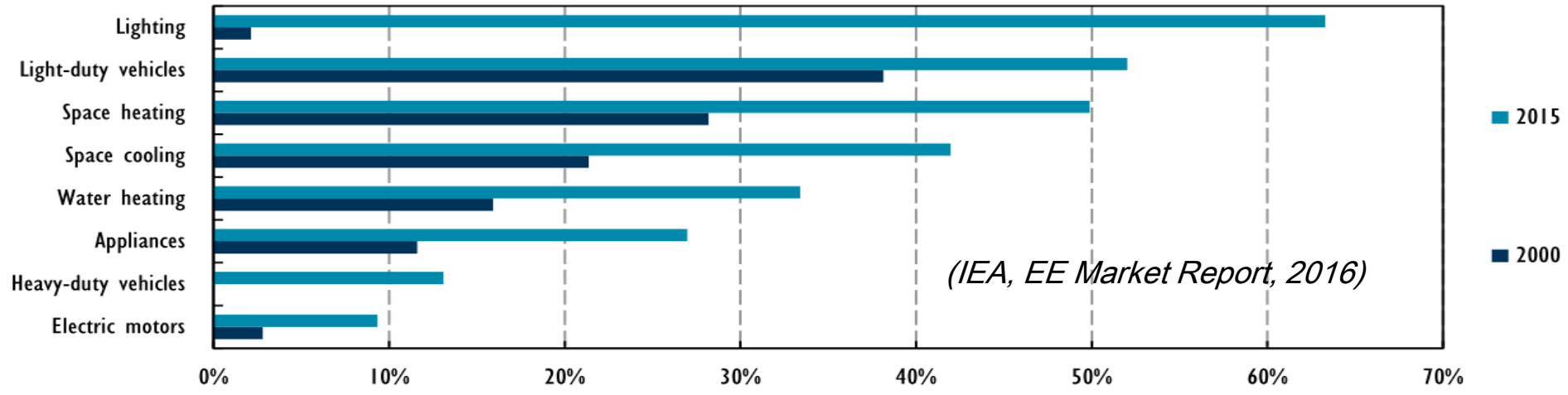



**Figure 3.8** Share of global end-use energy consumption covered by mandatory energy efficiency policies, 2000 and 2015




*(IEA, EE Market Report, 2016)*

# .. for selected countries

**Figure 3.6** Share of TFC covered by mandatory energy efficiency standards and regulations

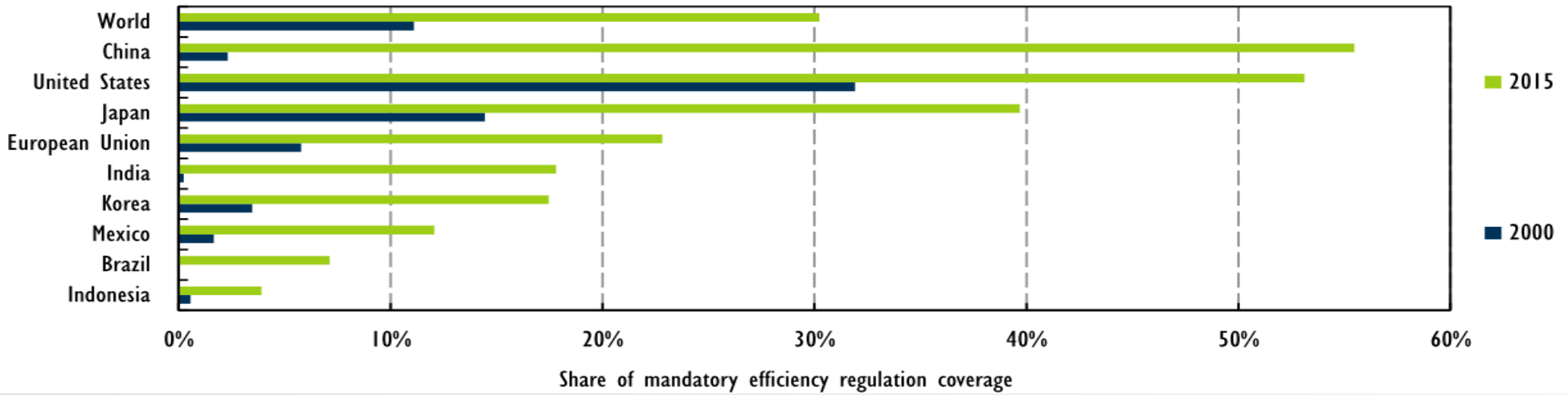
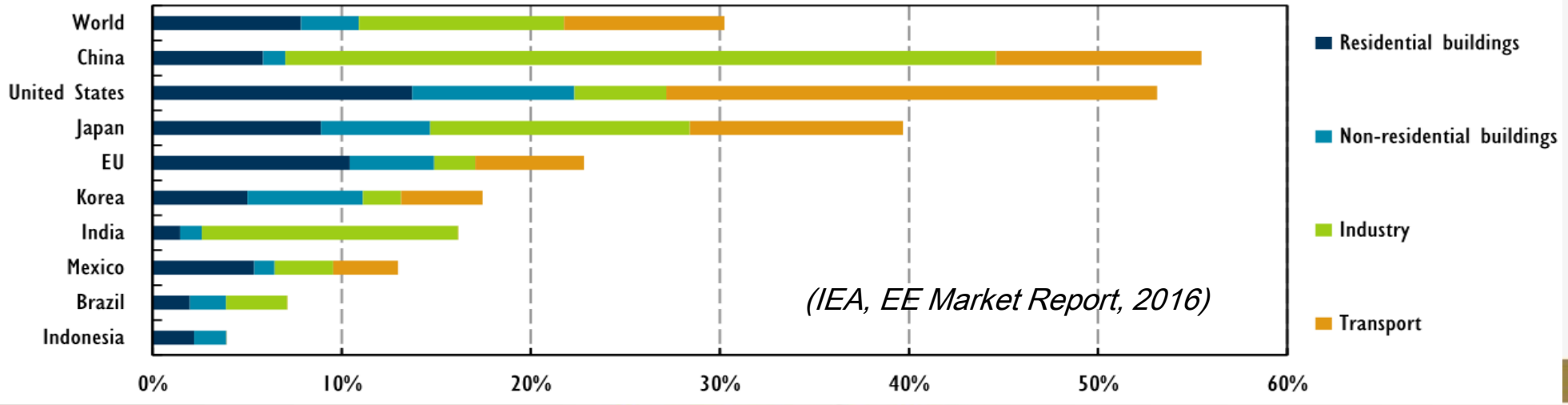
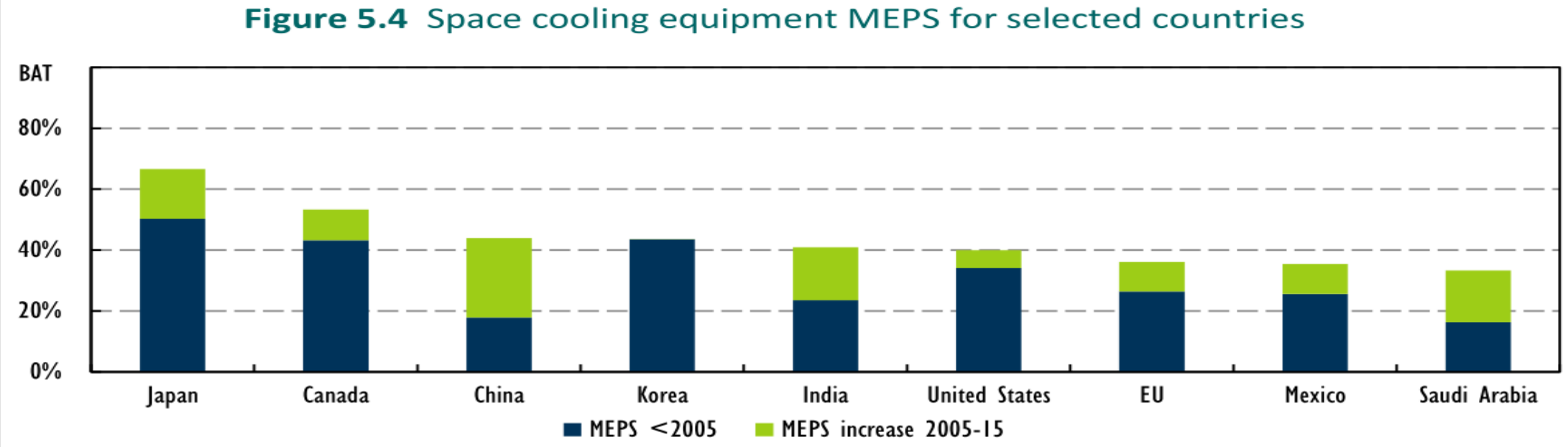



**Figure 3.7** Share of TFC covered by mandatory energy efficiency policy by sector



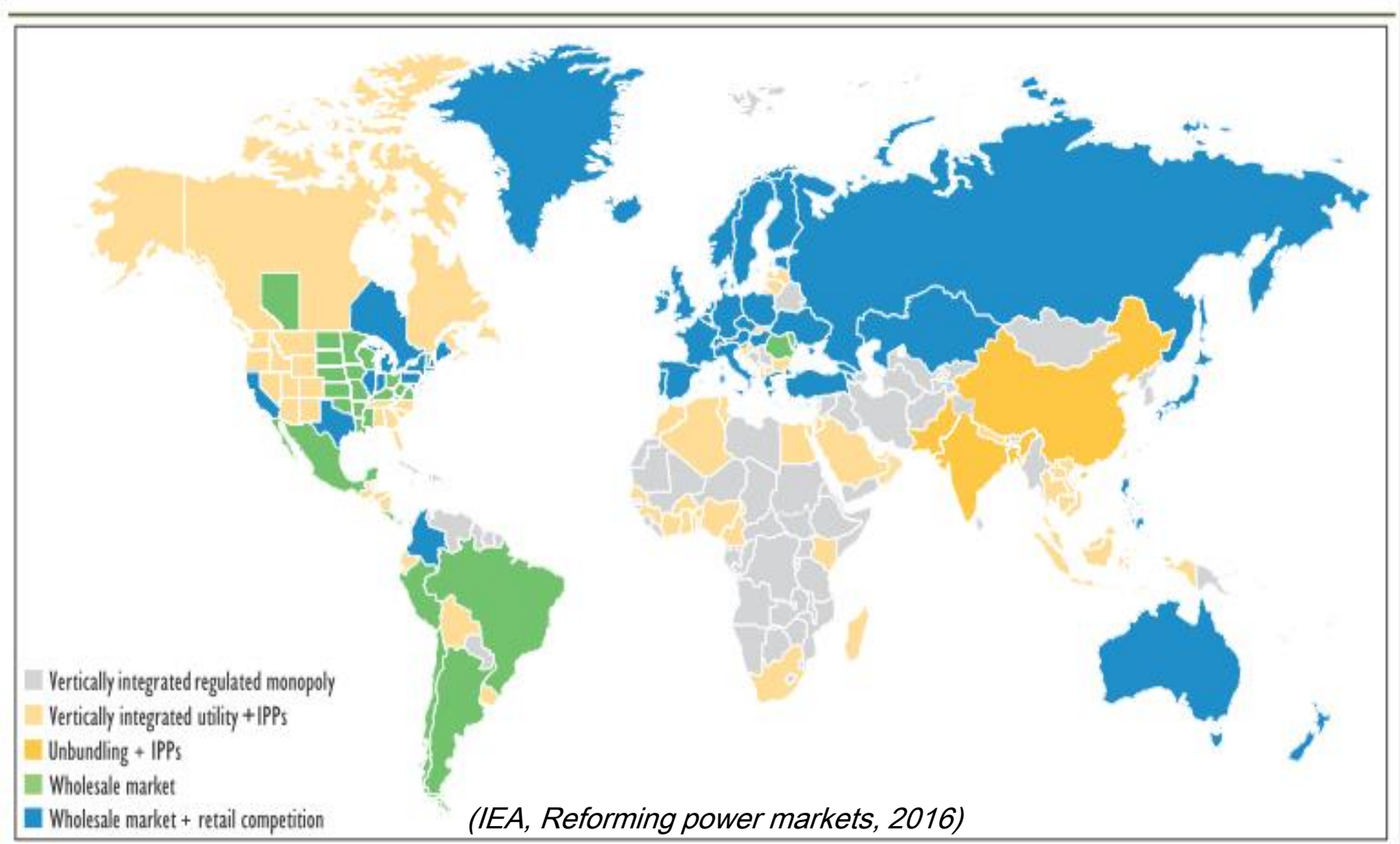

*(IEA, EE Market Report, 2016)*

# More can be done – scope, extent




*(IEA, EE Market Report, 2016)*

# Energy market arrangements effectively place ‘price’ on, and context for, energy efficiency




*(IEA, Reforming power markets, 2016)*

# Specific market-based instruments

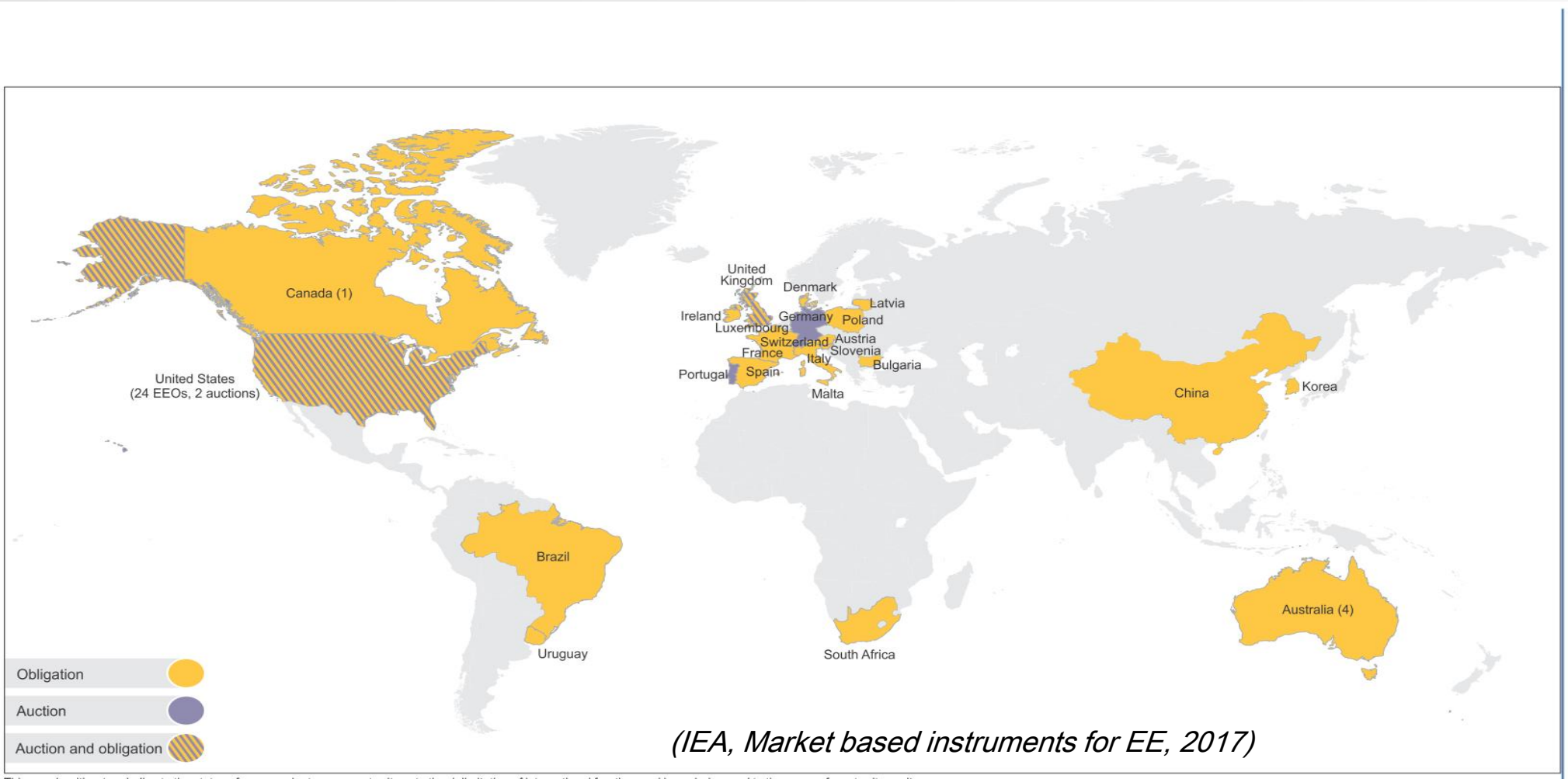
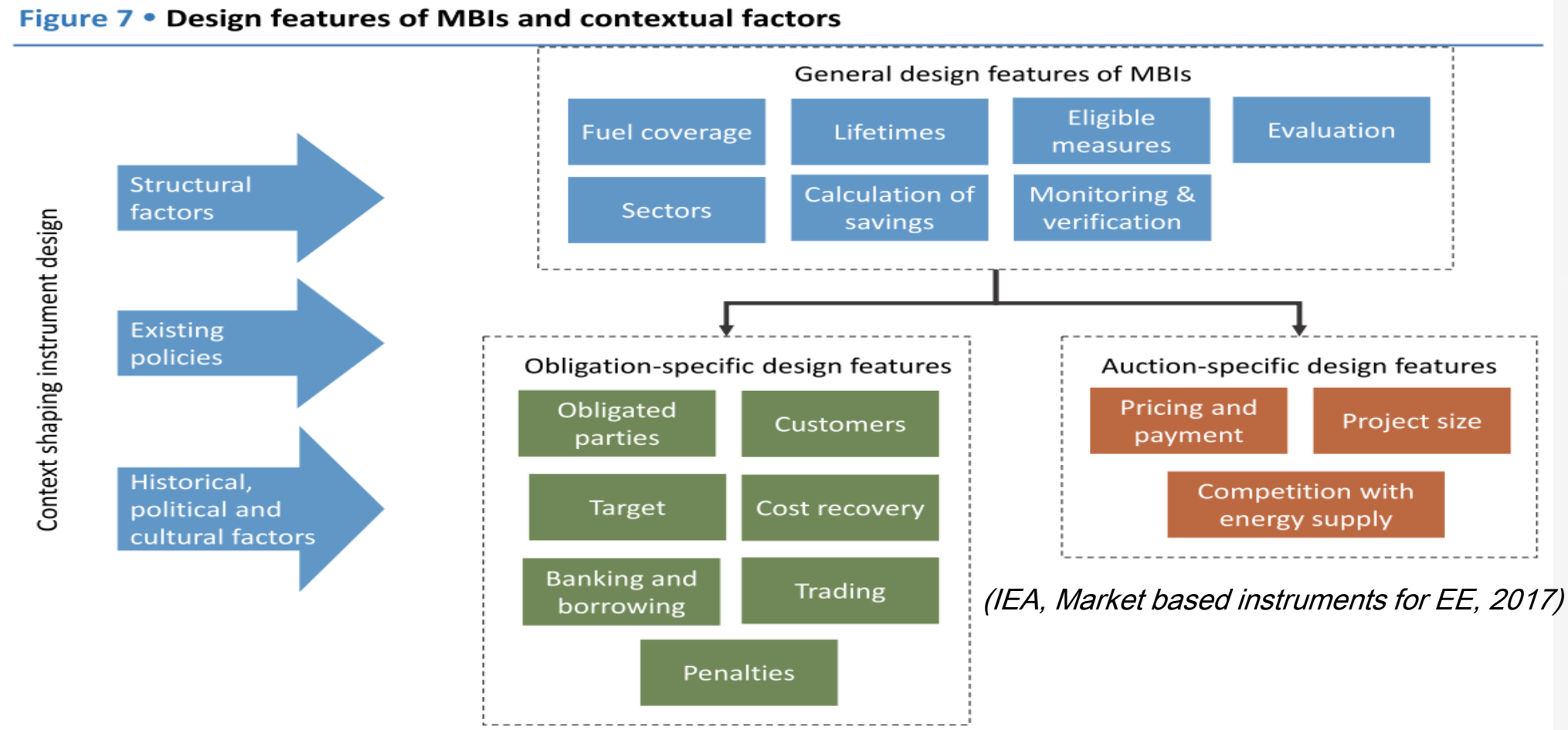



Figure 3 • Global coverage of MBIs for energy efficiency

*(IEA, Market based instruments for EE, 2017)*

# … involve considerable complexities




*(IEA, Market based instruments for EE, 2017)*

# Overall status and next steps

## 2.2 Energy demand

| Overall on track? | Recent trends |
|---|---|
| ● Not on track<br>● Improvement, but more effort needed<br>● On track, but sustained deployment and policies required | ↘ Negative developments<br>~ Limited developments<br>↗ Positive developments |

| Industry | ↗ |
|---|---|
| Decoupling of industrial production from $CO_2$ emissions is critical to achieve the 2DS targets. Annual growth in $CO_2$ emissions between 2014 and 2025 needs to be limited to 0.1%, compared to 1.1% in the current pathway, with peaking of industrial $CO_2$ emissions by 2020. | The industrial sector has continued to progress in energy efficiency and low-carbon technology deployment, limiting its final energy consumption y-o-y growth to 1.3% in 2014. To meet the 2DS, action must accelerate to limit the growth in energy consumption to 1.2% per annum by 2025 and stabilize $CO_2$ emissions. |

**Recommendation for 2017:** Incentivise energy efficiency improvements through mechanisms facilitating retrofitting of existing capacity and deployment of current best available technologies.

| Chemicals and petrochemicals | ↗ |
|---|---|
| Average annual growth in the sector's final energy consumption and direct energy-related $CO_2$ emissions was 2.3% and 2.6%, respectively, during 2000-14, slowing down mainly by switching to lighter feedstocks made economical by price trends in some regions. This trend towards lower $CO_2$ emissions feedstocks must be sustained in the long term to bring the sector on track to meet the 2DS. Annual increases in process energy consumption and direct $CO_2$ emissions must stay below 3.1% and 2.8%, respectively, in spite of considerable production increases. | The chemicals and petrochemicals sector has made progress in shifting towards lower-carbon feedstocks in recent years, driven by price changes in some regions. |

**Recommendation for 2017:** Improve publicly available statistics for the chemicals and petrochemicals sector, so as to robustly track progress and set appropriate targets for emissions reductions.

*(IEA, Energy Technology Perspectives, 2017)*

| Buildings | ↗ |
|---|---|
| Global average building energy use per person since 1990 has remained constant at 5 MWh per person per year. This rate would need to decrease to less than 4.5 MWh per person by 2025 to be in line with 2DS targets. Furthermore, current investments in building energy efficiency are not on track to achieve the 2DS targets. | Average global building energy intensity per square metre only improved by 1.3% last year, while total floor area grew by 3%. Progress in some countries is promising, but overall, buildings are still not on track to meet 2DS objectives by 2025. |
| **Recommendation for 2017:** Countries can take immediate action to put forward commitments for low-carbon and energy-efficient buildings to implement their NDCs as a first step and a clear signal to scale up actions across the global buildings sector. | |

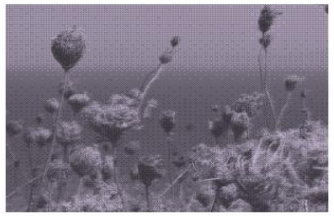
| Building envelopes | ~ |
|---|---|
| Global annual average building envelope energy intensity improvements of 1.4% have been achieved since 2010. Building envelope intensities need to improve by 30% by 2025 to keep pace with growth in floor area and the demand for greater comfort. | Progress on building energy codes in developing regions last year is a positive step toward 2DS ambitions, but two-thirds of countries still do not have mandatory building energy codes in place. |
| **Recommendation for 2017:** Global co-operation should seek to ensure that all countries implement and enforce building energy codes and standards for both new and existing buildings, with improvement in enforcement and verification of codes and standards to overcome barriers to their implementation. | |

| Lighting, appliances and equipment | ↗ |
|---|---|
| Electricity consumption by lighting, appliances and building equipment needs to halve from the current 3% average increase per year over the last decade to a 1.5% annual increase in the 2DS. | The growing shift to light-emitting diodes (LEDs) in the last two years is encouraging, with LEDs representing 15% of total residential lamp sales in 2015 (expected to have grown to nearly 30% in 2016). Effort is needed in markets everywhere to ensure that progress carries over to high-performance appliances and equipment. |
| **Recommendation for 2017:** Countries should seize on momentum under the recent Kigali Agreement to rapidly move global markets for cooling equipment to much higher energy performances. | |

*(IEA, Energy Technology Perspectives, 2017)*

# Some regional recommendations

## Cross-sectoral

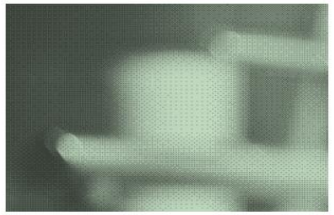


1 Establish energy data collection capacity
2 Develop national energy efficiency plans
3 Facilitate private investment
4 Designate lead energy efficiency institutions
5 Progressively remove energy price subsidies

## Buildings

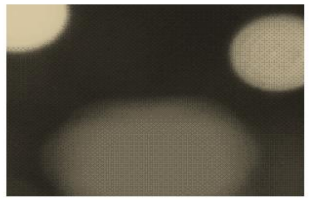
6 Require and enforce building energy codes
7 Support energy-efficient building renovations
8 Encourage use of high-efficiency building components

## Appliances & Equipment



9 Require minimum energy performance standards for appliances
10 Monitor, verify and enforce standards

## Lighting

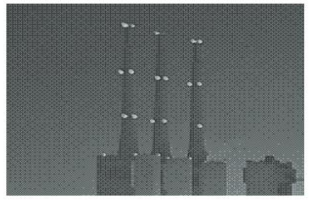


11 Phase-out energy-inefficient lamps
12 Put in place high-efficiency street lighting

## Transport

13 Require fuel economy standards for vehicles
14 Encourage light duty vehicle fleet renewal
15 Promote eco-driving
16 Support public transport development

## Industry



17 Require adherence to energy management protocols
18 Require minimum energy performance standards for equipment
19 Promote energy efficiency for small and medium enterprises (SMEs)
20 Put in place complementary policies to support industrial energy efficiency

*(IEA, Regional EE policy recommendations for the Arab SEMED Region, 2014)*