Mitigation in the context of
urban development and the built environment
What do these mean for Africa?

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Midrand, South Africa

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Outline

- A substantial share of emission increase in Africa in the next few decades will come from cities
- A broad diversity of opportunities exist to keep these emissions at bay while even increasing services
  - Urban form
  - Building energy efficiency
  - Embodied energy and emissions in infrastructure
- Energy efficiency has been a very powerful tool to keep emissions and energy use at bay worldwide
- Many energy efficiency opportunities exist that also contribute to development goals rather than compromise them
- However, there is a major lock-in risk

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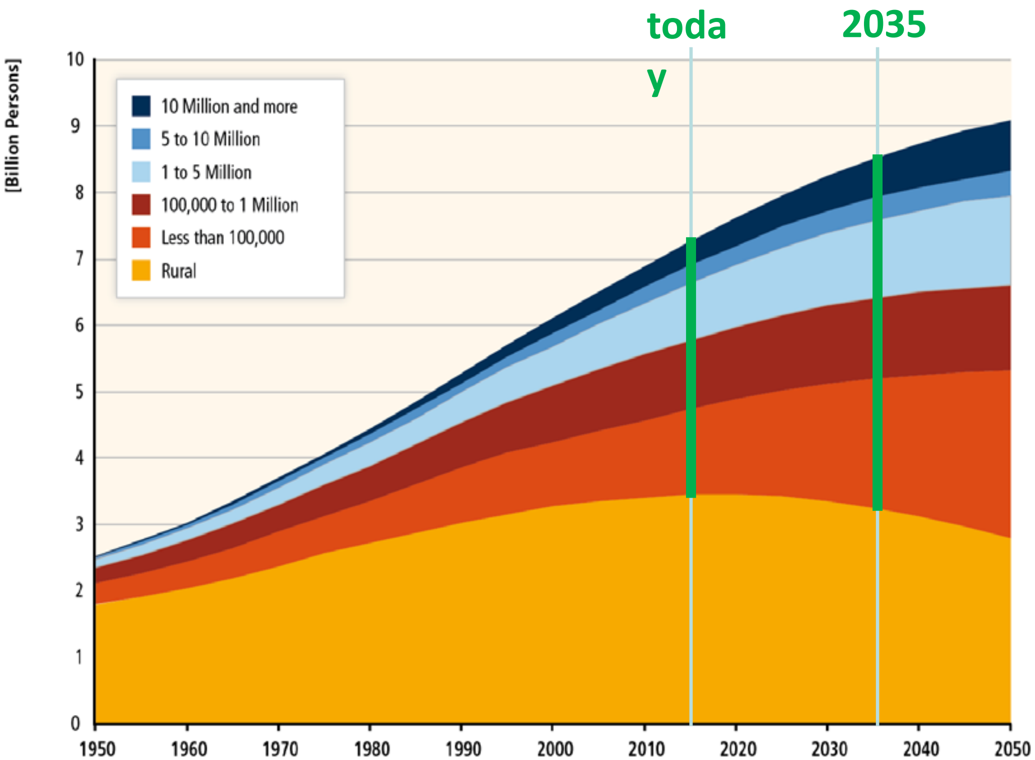

A substantial share of emission increase in Africa in the next few decades will come from cities

- Urban areas generate 80% of GDP and 71% - 76% of CO_2 emissions from global energy use
- Each week the urban population increases by 1.3 million
- By 2050 urban population is to increase by up to 3 billion
- Over 70% of global building energy use increase will take place in developing country cities
- This enormous expected increase poses both an opportunity and responsibility

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A broad diversity of opportunities exist to keep these emissions at bay while increasing services

- Urban design and form
- Energy efficient buildings
  - low-energy architecture
    - avoiding cooling needs
  - High-efficiency appliances, lighting and equipment
  - High performance operation of buildings (mainly commercial)
- Fuel switch to low-carbon energy sources (RES) or high-efficiency equipment using energy contributing to CC
  - Hi eff cookstoves
- Lowering embodied energy in the built infrastructure –
  - affordable low-carbon, durable construction materials

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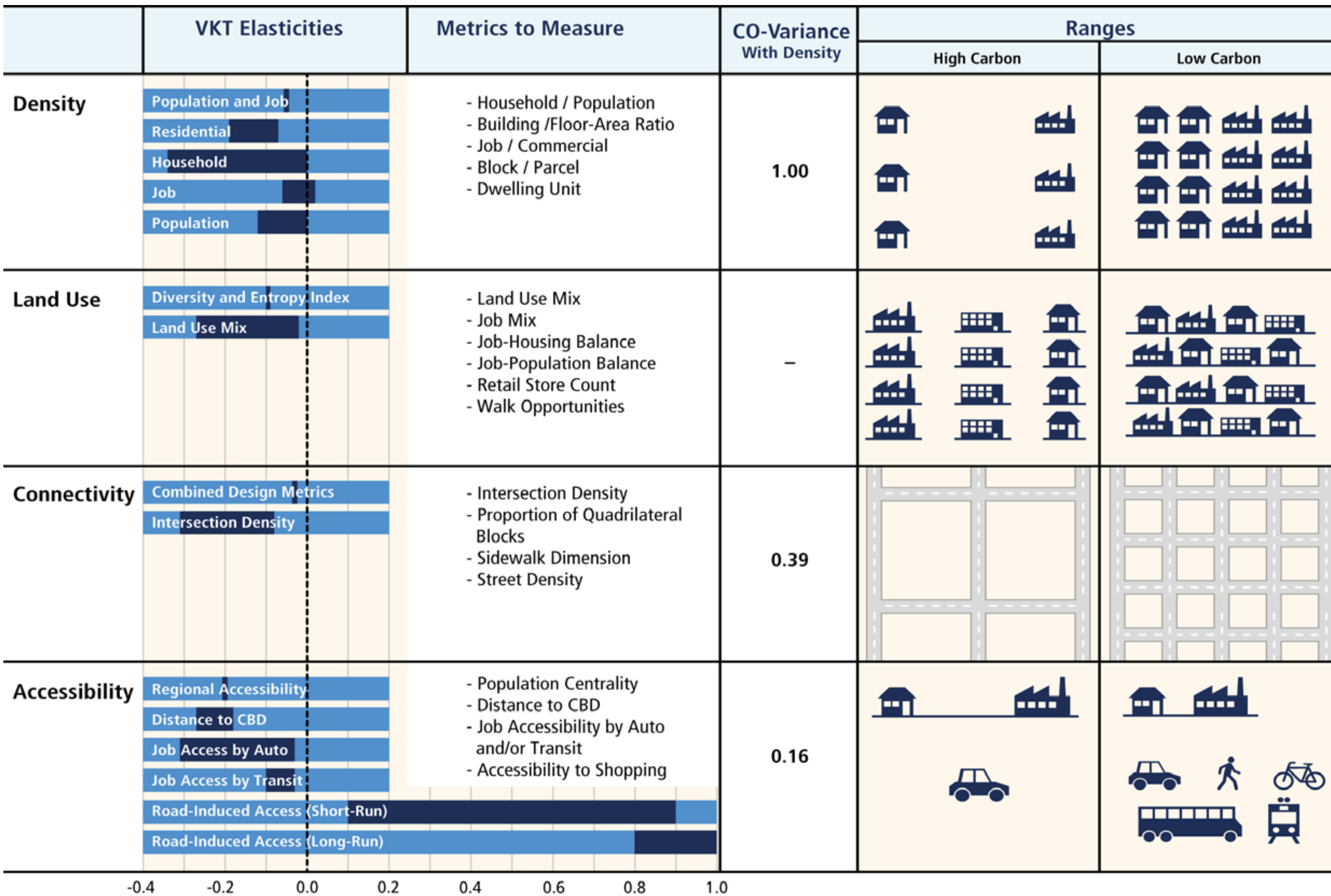
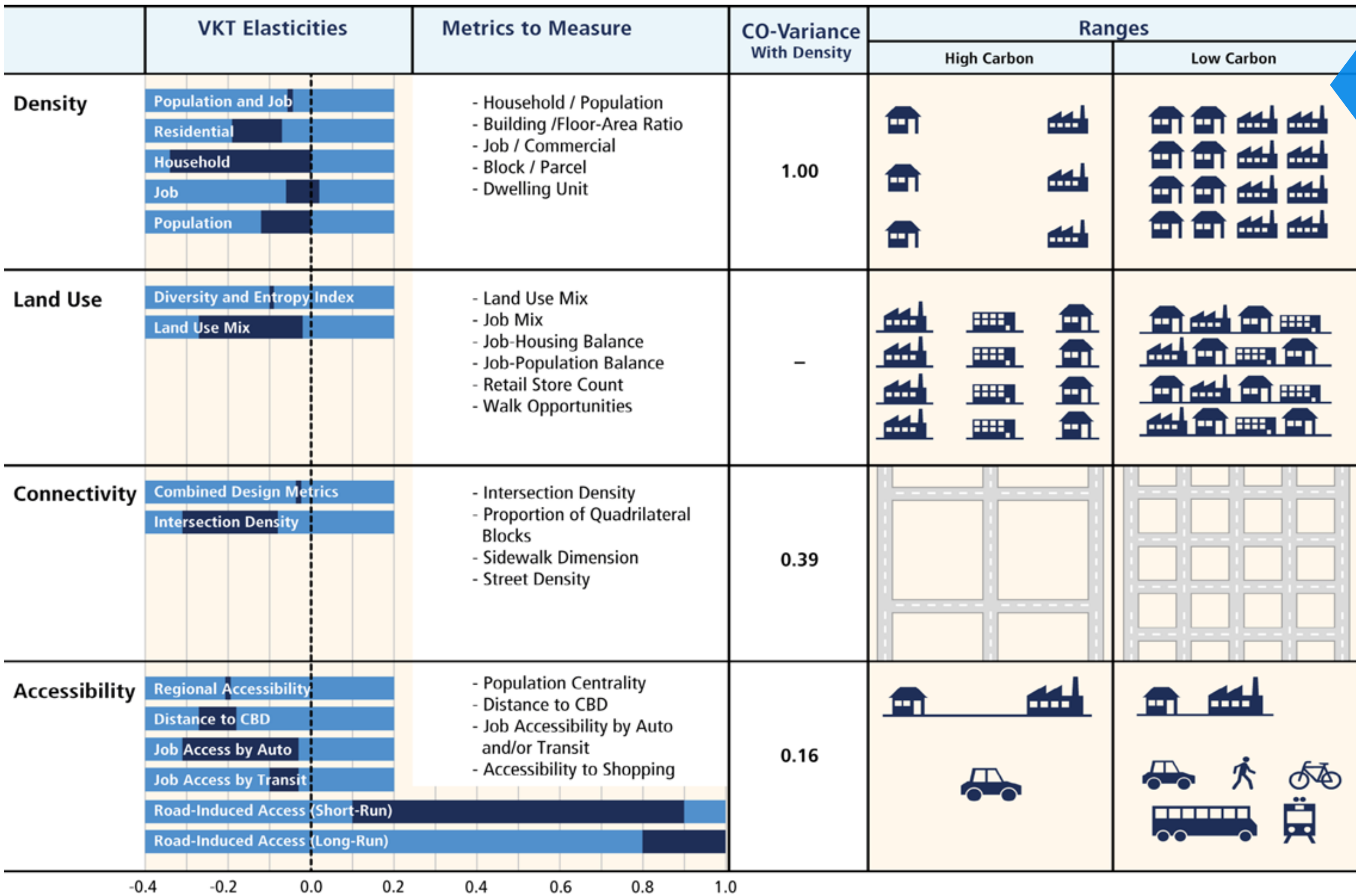
Mitigation through urban design

Infrastructure and urban form are strongly linked and lock-in patterns of land use, transport and housing use, and behavior

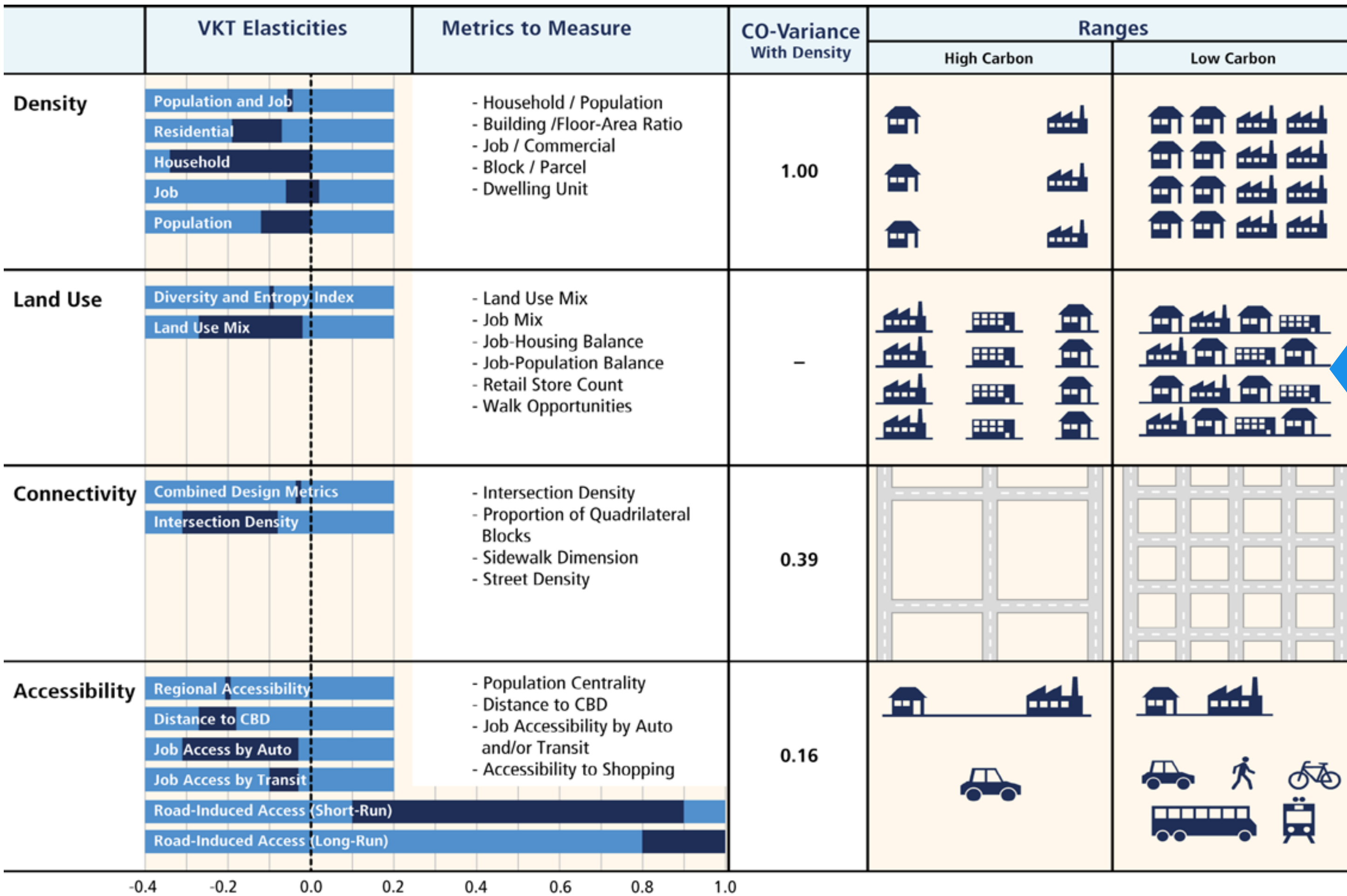


Increasing and co-locating residential and employment densities can lower emissions



Higher density leads to less emissions (i.a. shorter distances travelled).

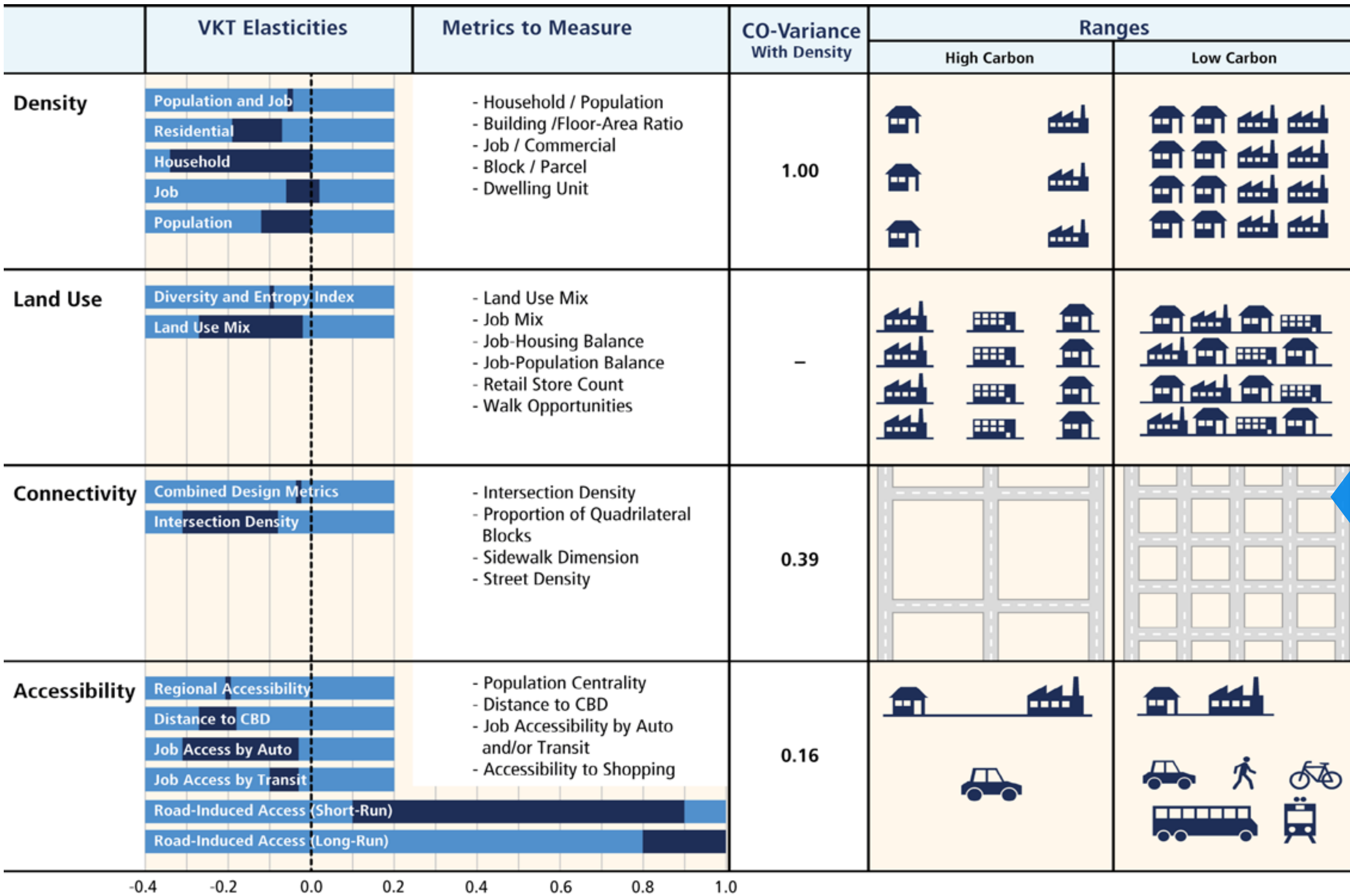
Increasing land use mix can significantly reduce emissions



Mix of land-use reduces emissions.

To lower urban emissions, need diverse urban land use mix

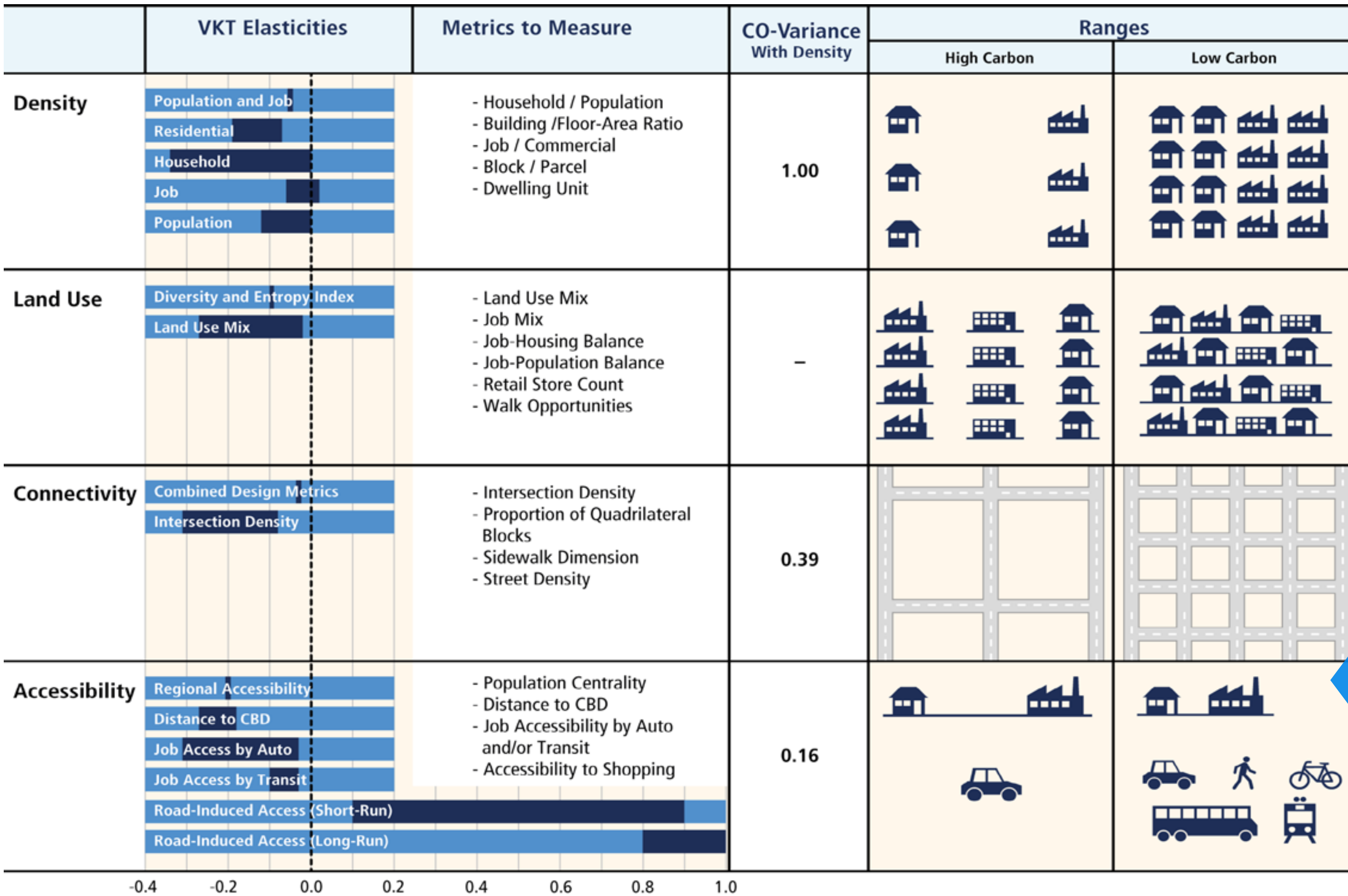
Increasing connectivity can enable multiple modes of transport



Improved infrastructural density and design (e.g. streets) reduces emissions.

Working Group III contribution to the IPCC Fifth Assessment Report

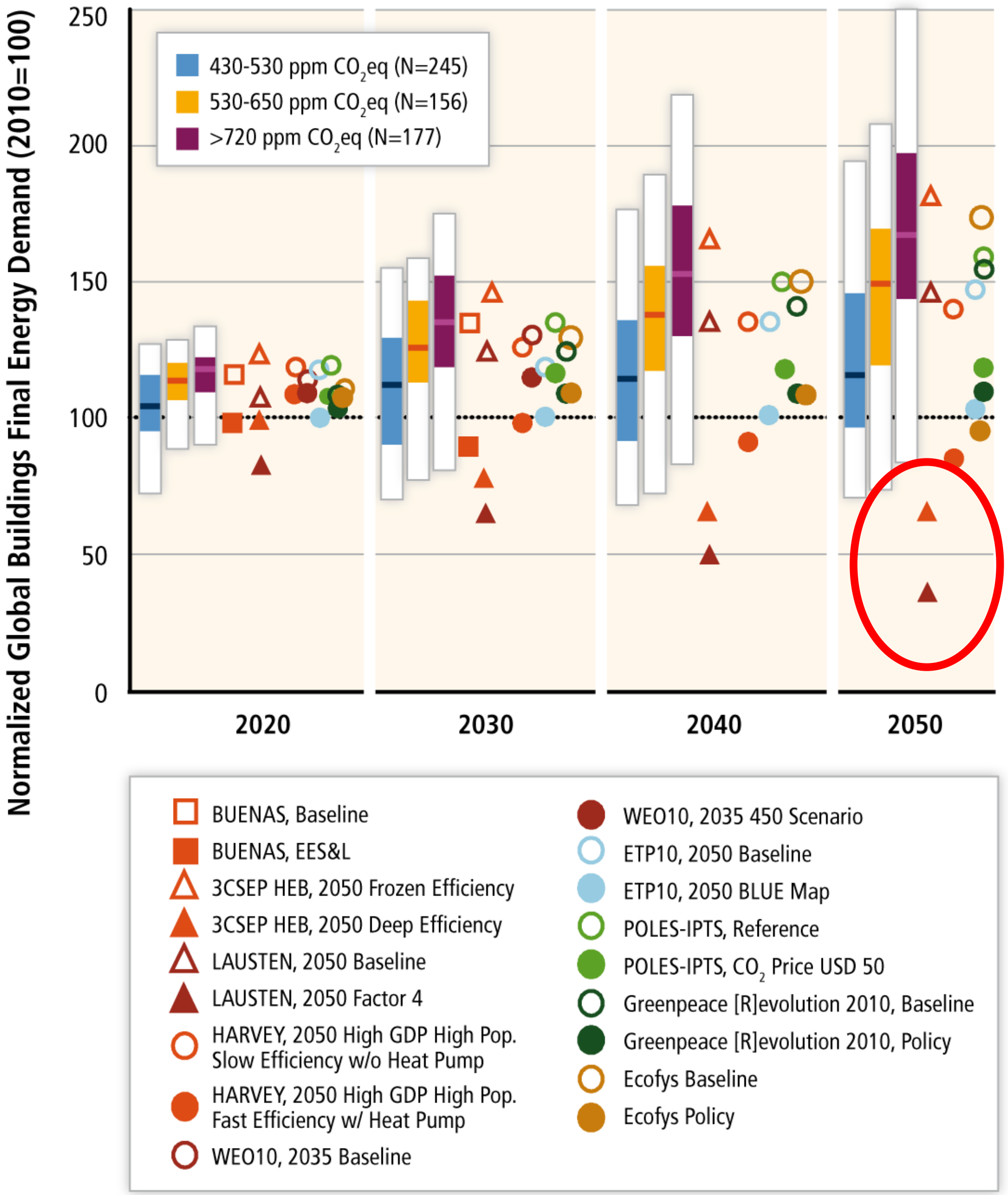
Co-location of activities reduces direct and indirect GHG emissions



Accessibility to people and places (jobs, housing, services, shopping) reduces emissions.

Mitigation opportunities through urban planning:

1. increasing accessibility
2. increasing connectivity
3. increasing land use mix
4. increasing transit options
5. increasing and co-locating employment and residential densities
6. increasing green space and other carbon sinks
7. Increasing white and light-colored surfaces



Energy efficiency in buildings can substantially lower sectoral energy use; thermal uses are most reducible

for further details on mitigation options and potentials, see Chapter 9

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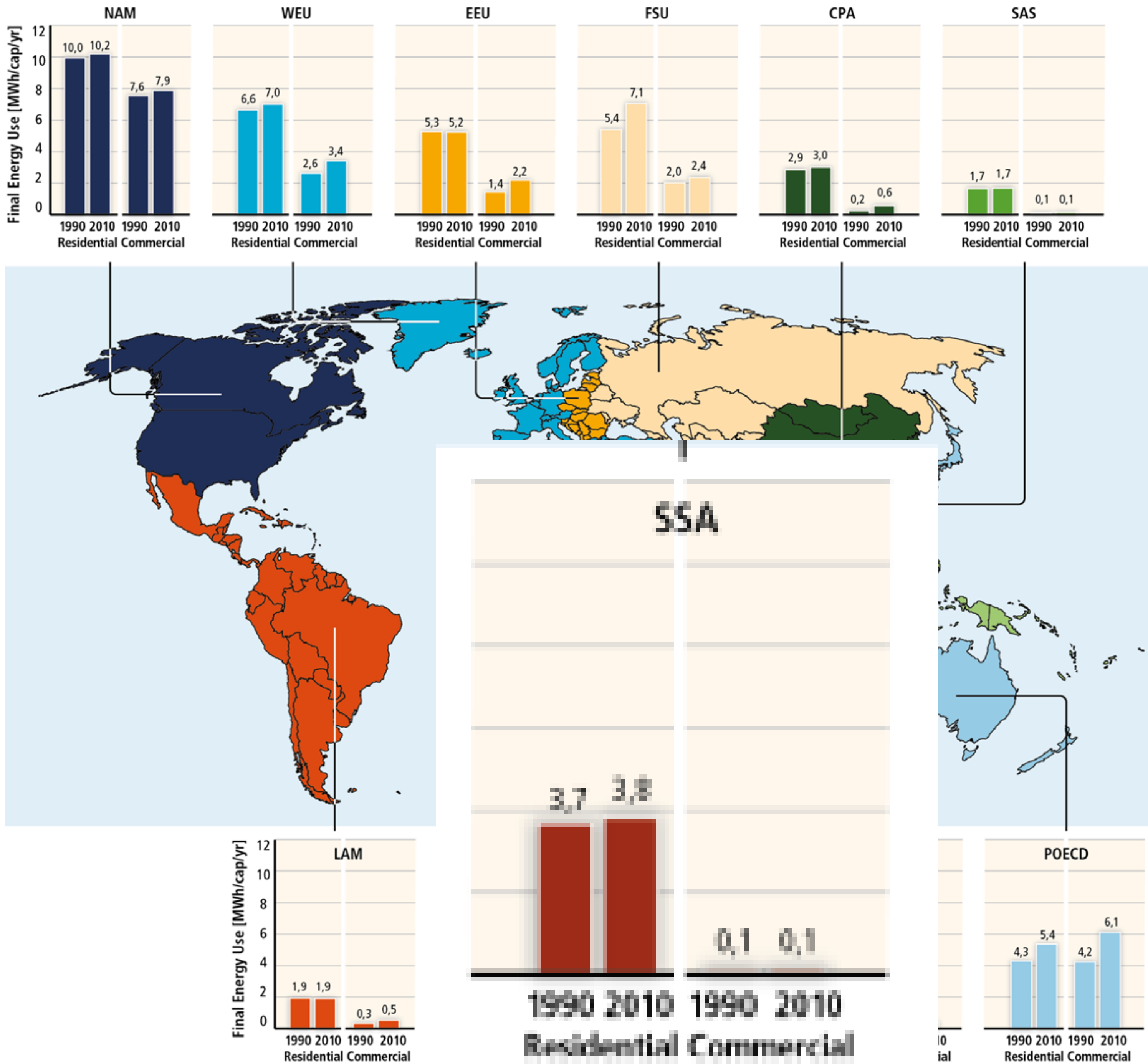
Increased efficiency has been a very powerful tool to keep emission and energy demand increases at bay for decades

Per capita residential and commercial energy use, 1990 - 2010



Urban and buildings-level mitigation options can also contribute towards development goals

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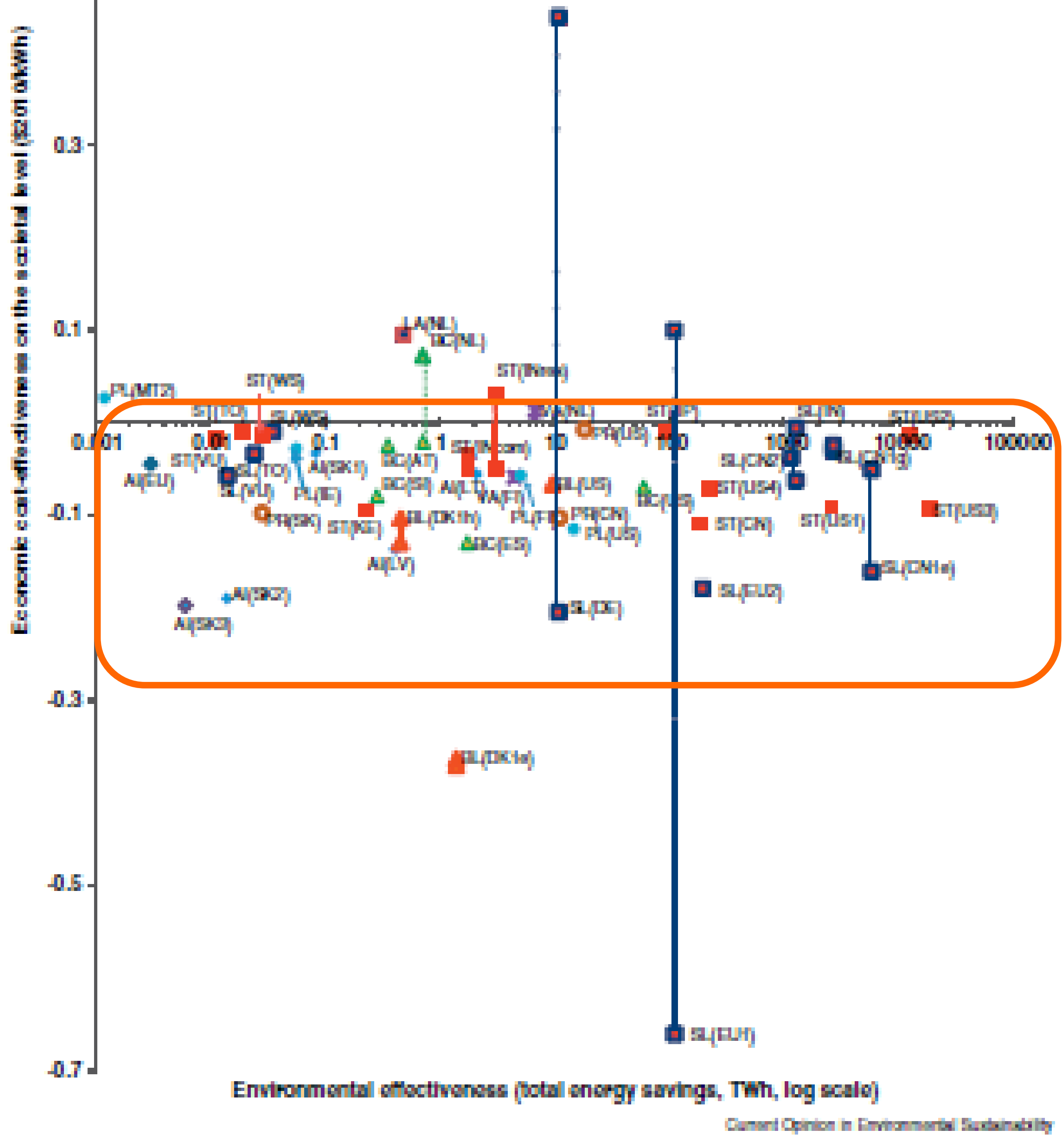
"Overall, the potential for co-benefits for energy end-use measures outweigh the potential for adverse side-effects, whereas the evidence suggests this may not be the case for all energy supply and AFOLU measures." (SPM 4.1)

How mitigation options can go hand-in-hand with development goals in Africa (co-benefits)

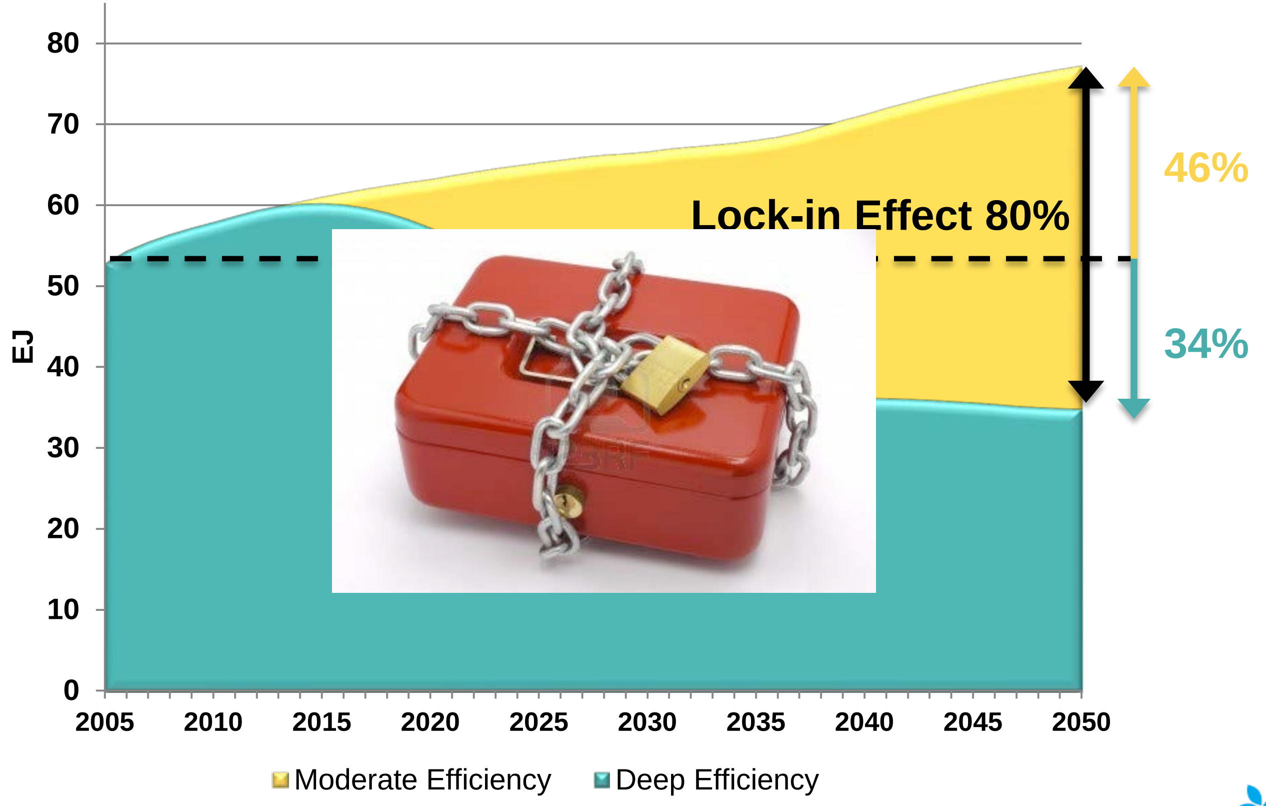
- Health – 2 m annually die from indoor air pollution from cooking, many women and children
- Increased productive time for women and children
- Air quality improvement – indoor and outdoor
- decreasing the burden of energy generation capacity development needs
- Efficiency increases access to energy services
  - Contribution to poverty alleviation
- Decreased needs for energy imports (energy security)
- Better employment and economic opportunities through accessivity
- Reduced congestion
- Several mitigation options in buildings have been shown to have net negative social mitigation costs

Cost of conserved carbon for implemented energy efficiency programs, post-ante evaluation results (based on data in Table 9.9 (boza-kiss et.al 2013 in COSUst)



However, there is a major lock-in risk

The Lock-in Risk: global heating and cooling final energy in two scenarios



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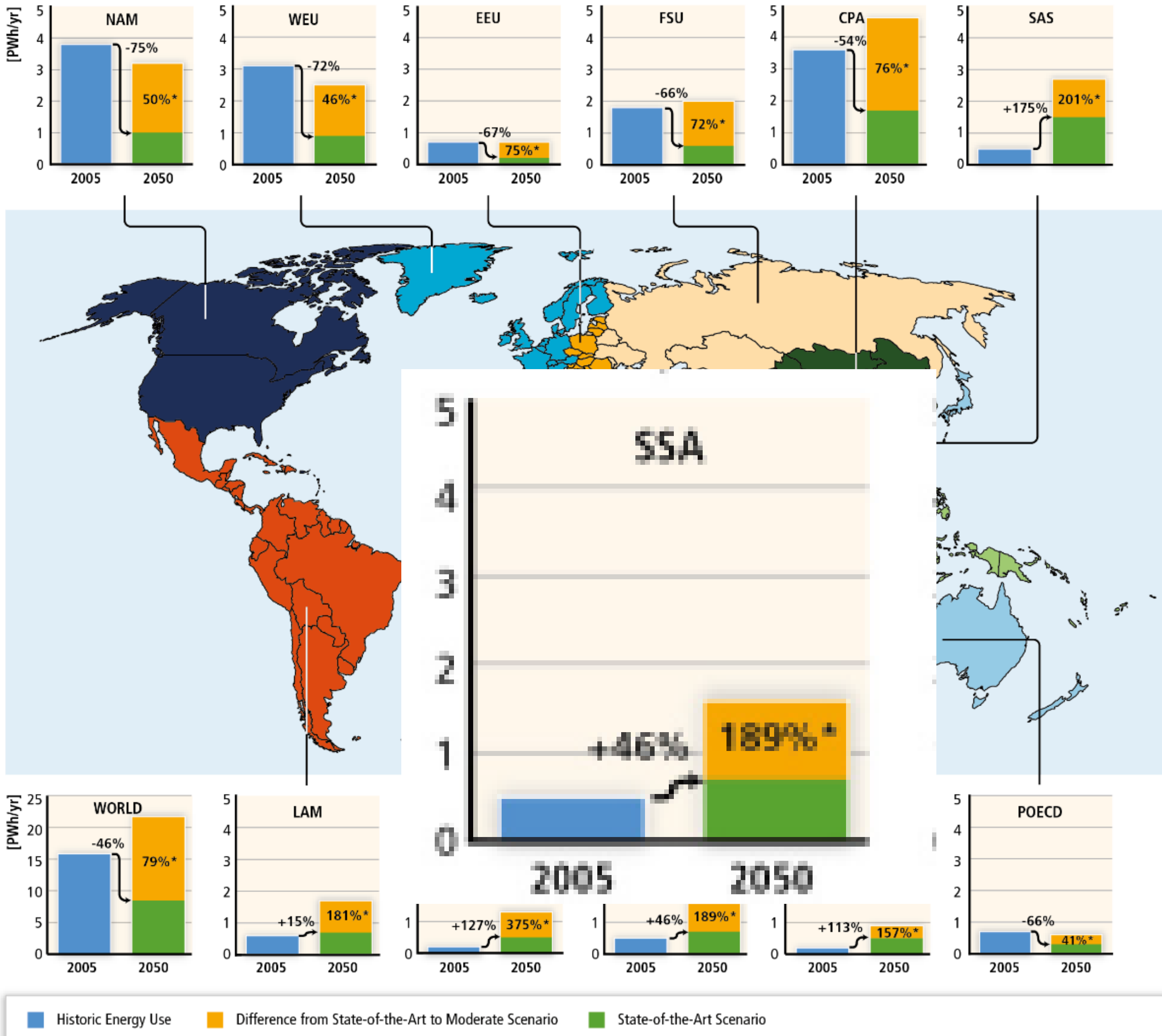
The lock-in risk: heating and cooling energy demand by two scenarios



*Lock-in Risk of Sub-Optimal Scenario Realative to Energy Use in 2005.

Thank you for your attention

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Supplementary slides

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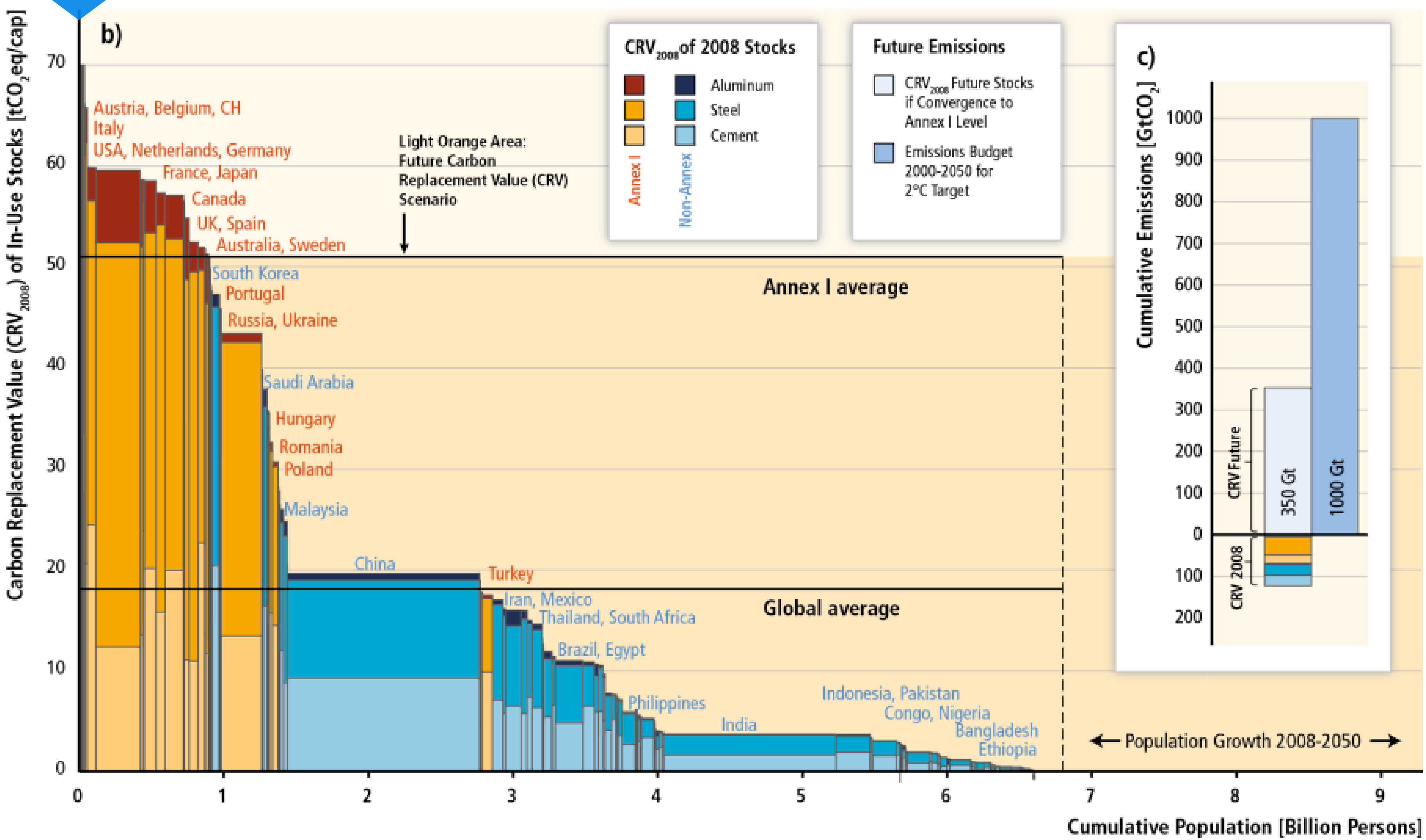
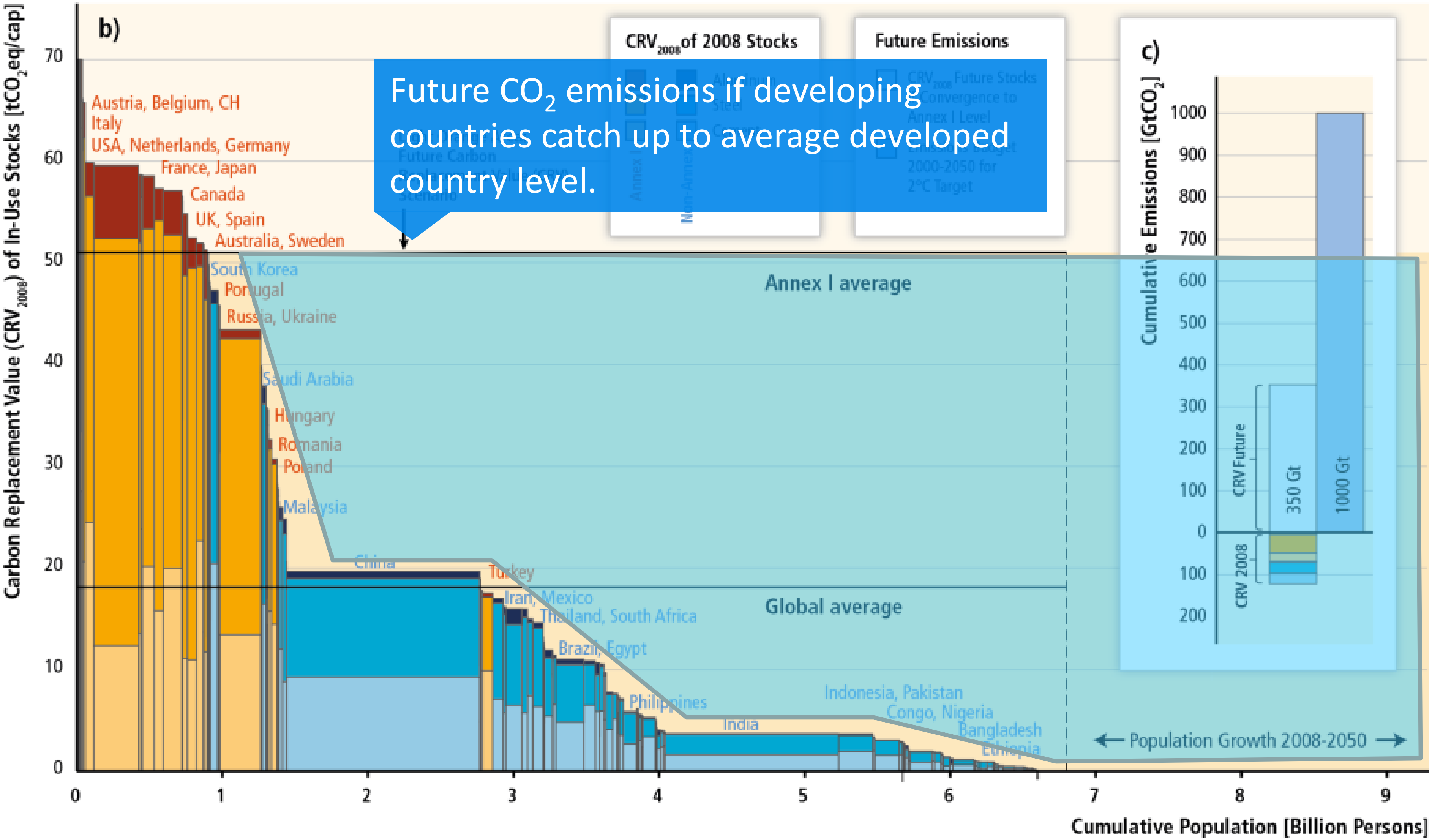
Key Message 4: Infrastructure build-up over the next few decades will result in significant emissions

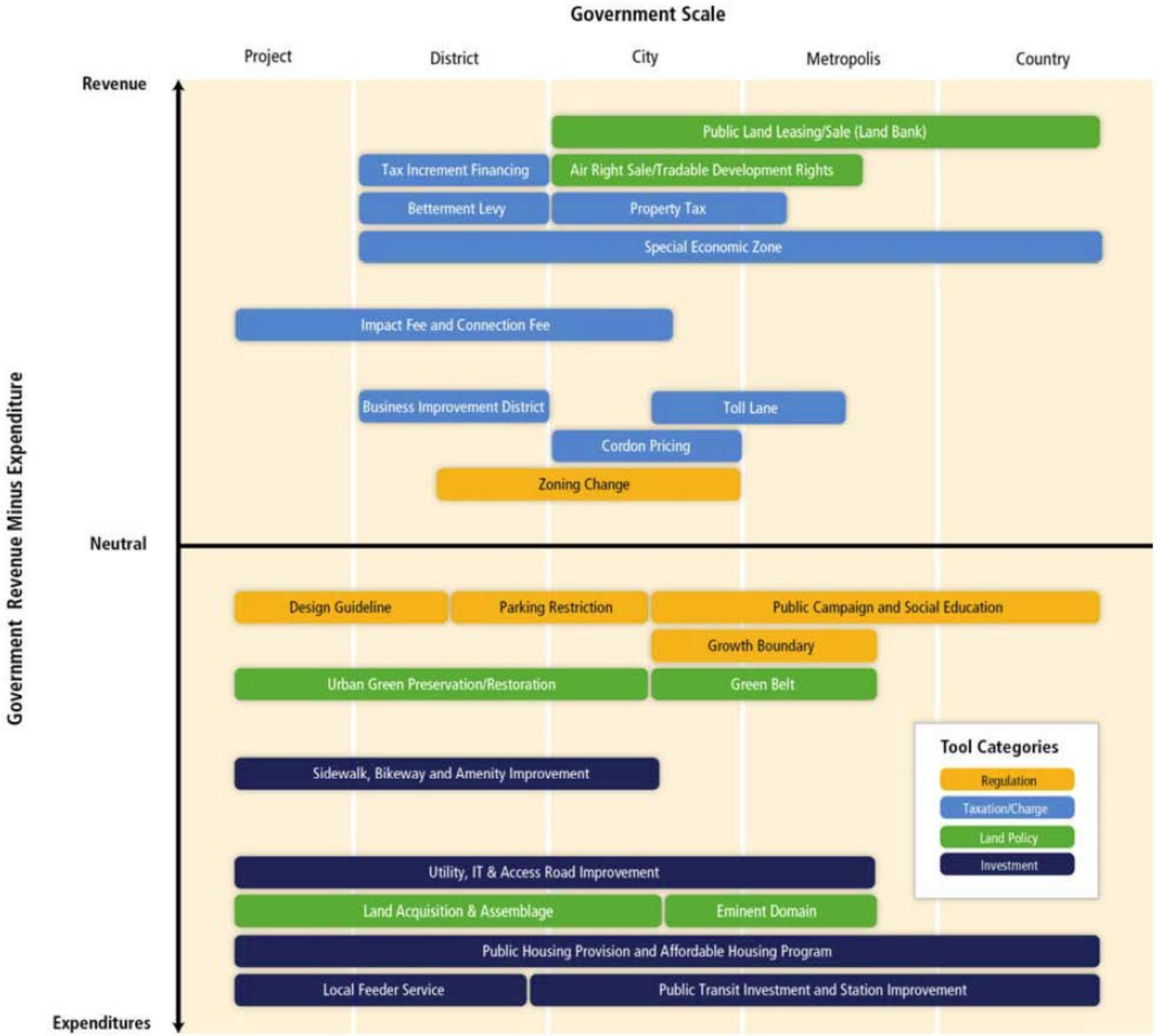
Total CO_2 emissions (per capita) needed to build up today's infrastructure



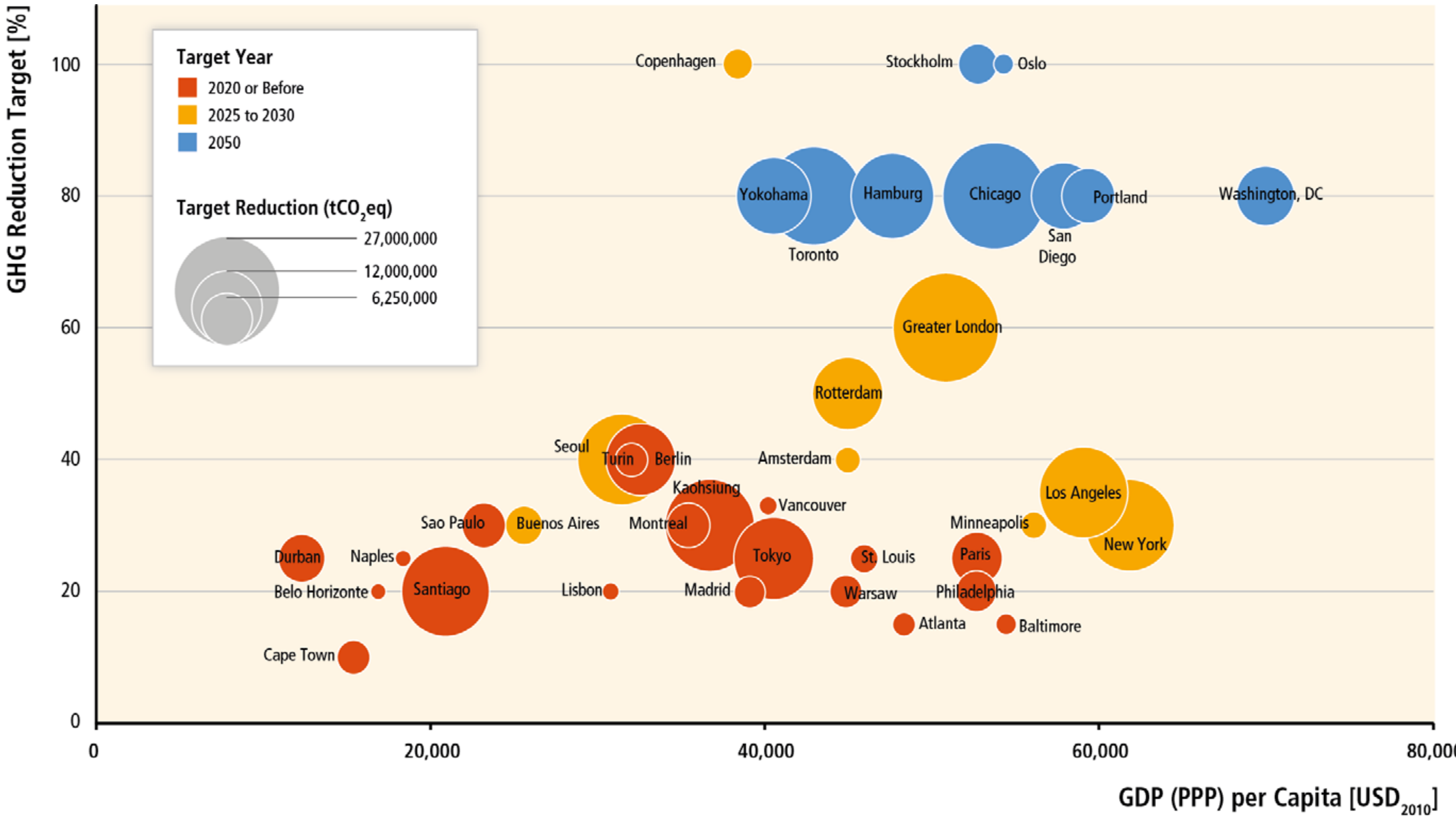
Key Message 4: Infrastructure build-up over the next few decades will result in significant emissions



Key Message 5: Large mitigation opportunities exist where urban form is not locked in, but often where there are limited financial and institutional capacities



Key Message 6: Thousands of cities are undertaking climate action plans, but their impact on urban emissions is uncertain



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Summary

1. Urban areas contribute considerably to global primary energy demand and energy-related CO_2 emissions.

2. The feasibility of spatial planning instruments for climate change mitigation depends highly upon each city's financial and governance capability.

3. Urban planning mitigation options include:
    1. increasing accessibility
    2. increasing connectivity
    3. increasing land use mix
    4. increasing transit options
    5. increasing and co-locating employment and residential densities
    6. increasing green space and other carbon sinks

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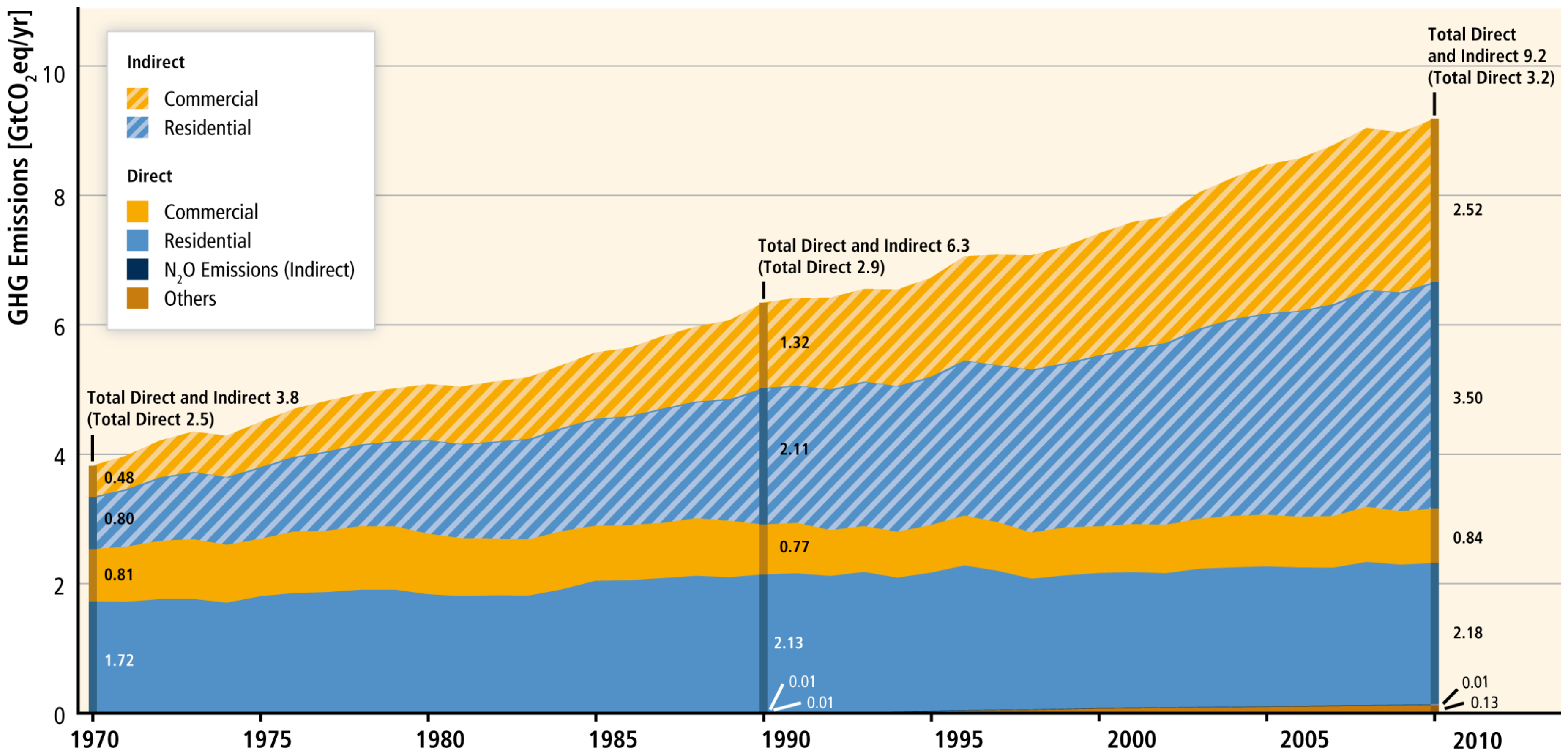
1. The building sector is responsible for a high share of emissions

In 2010, the building sector accounted for

- 117 EJ or 32% of global final energy
- 25% of energy-related CO2 emissions (9.2 Gt CO2e)
- 51% of global electricity consumption
- a significant amount of F-gas emissions: up to a third of all such emissions
- app. one-third of black carbon emissions



GHG Emissions [GtCO2eq/yr]
Indirect
Commercial
Residential
Direct
Commercial
Residential
N2O Emissions (Indirect)
Others
Total Direct and Indirect 3.8
(Total Direct 2.5)
0.48
0.80
0.81
1.72
Total Direct and Indirect 6.3
(Total Direct 2.9)
1.32
2.11
0.77
2.13
0.01
0.01
Total Direct
and Indirect 9.2
(Total Direct 3.2)
2.52
3.50
0.84
2.18
0.01
0.13
0
2
4
6
8
10
1970
1975
1980
1985
1990
1995
2000
2005
2010

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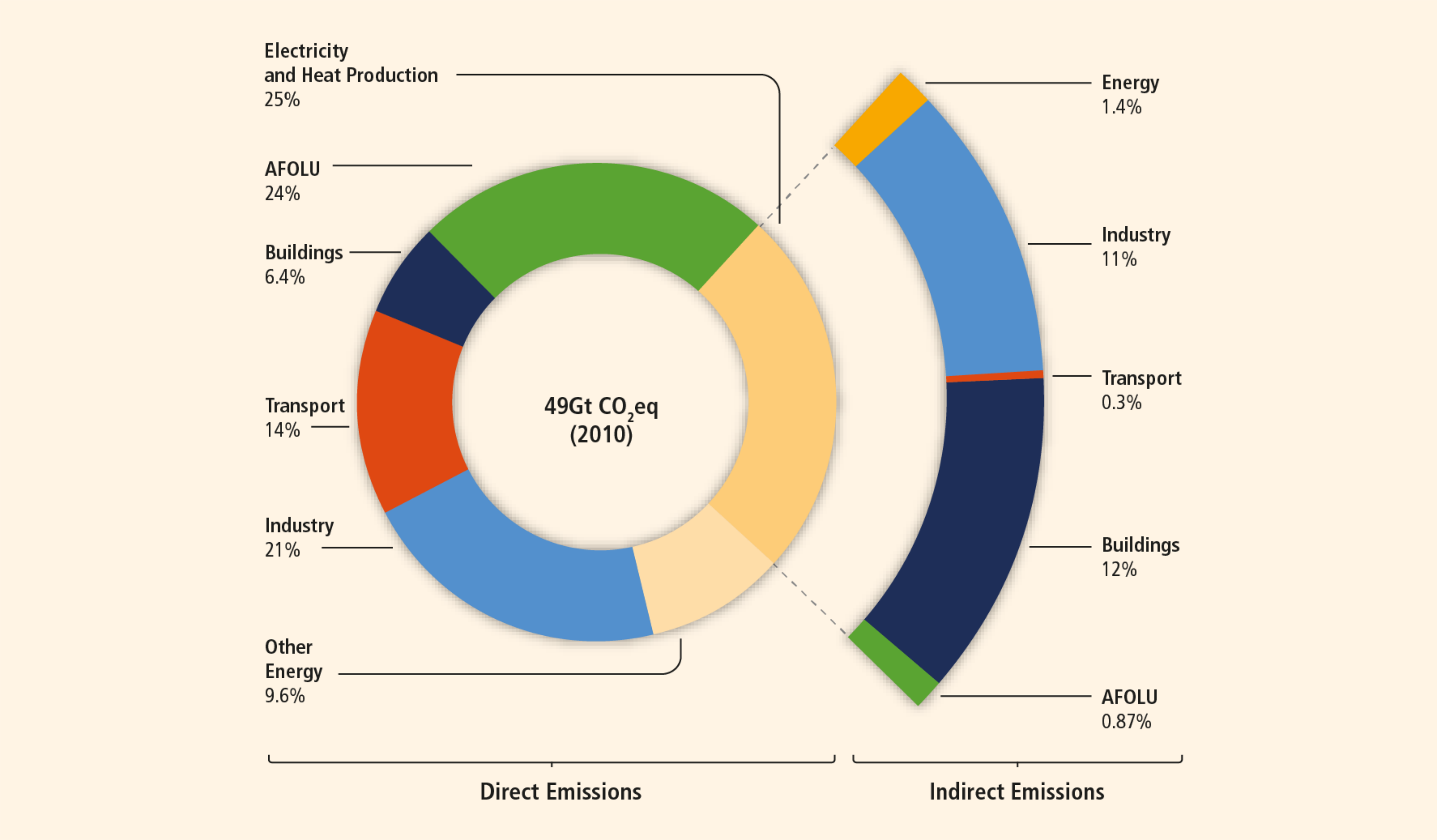
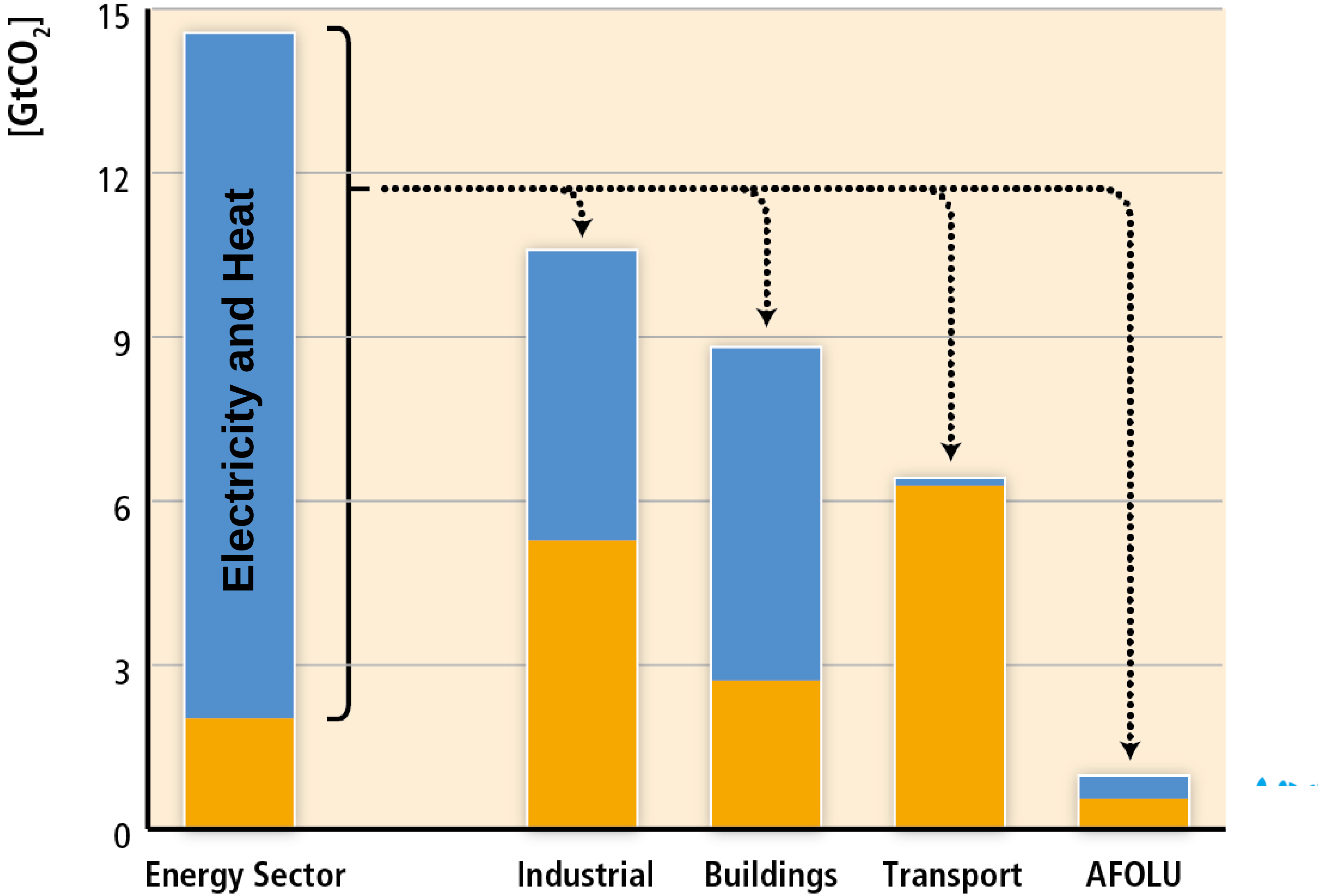
Challenge #1
but if only direct emissions are reported, buildings are insignificant



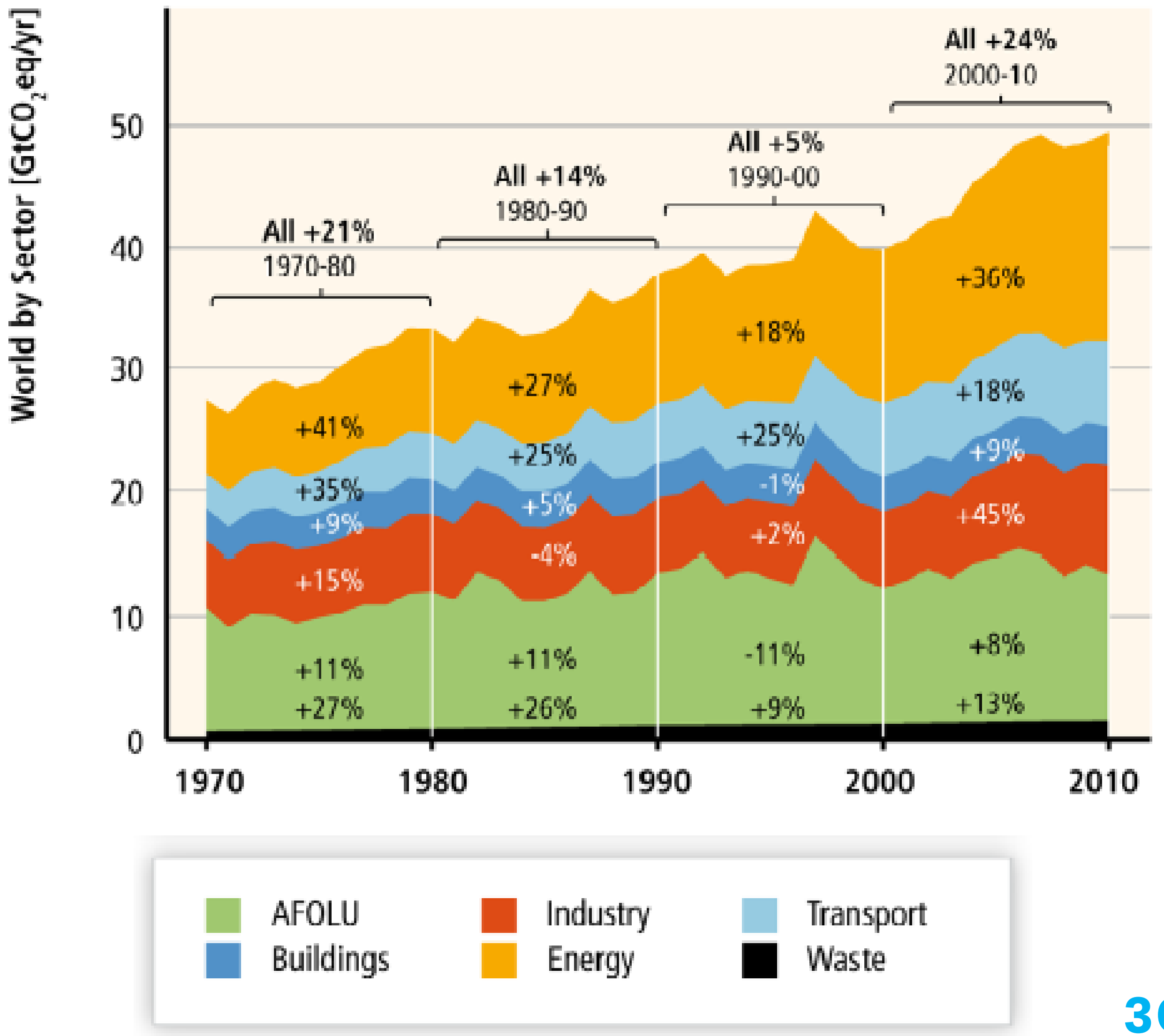
Allocation of Electricity/Heat Generation Emissions to End-use Sectors for 2010



Source: Figure A.II.2

Historical development of emissions by sector (fig 5.18)

(note: direct emissions only)



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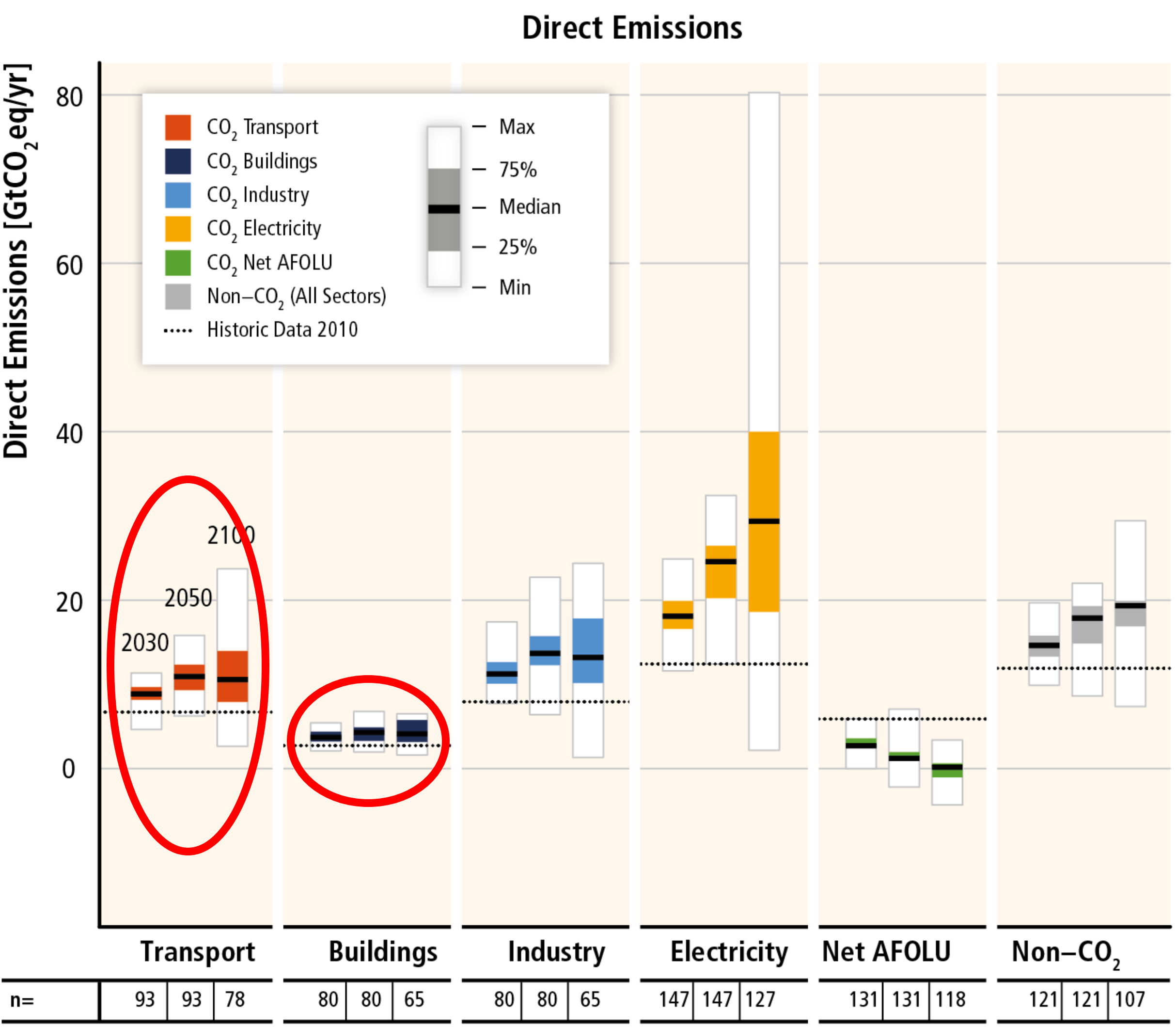
Baseline Scenarios: Direct vs. Indirect Emission Accounting



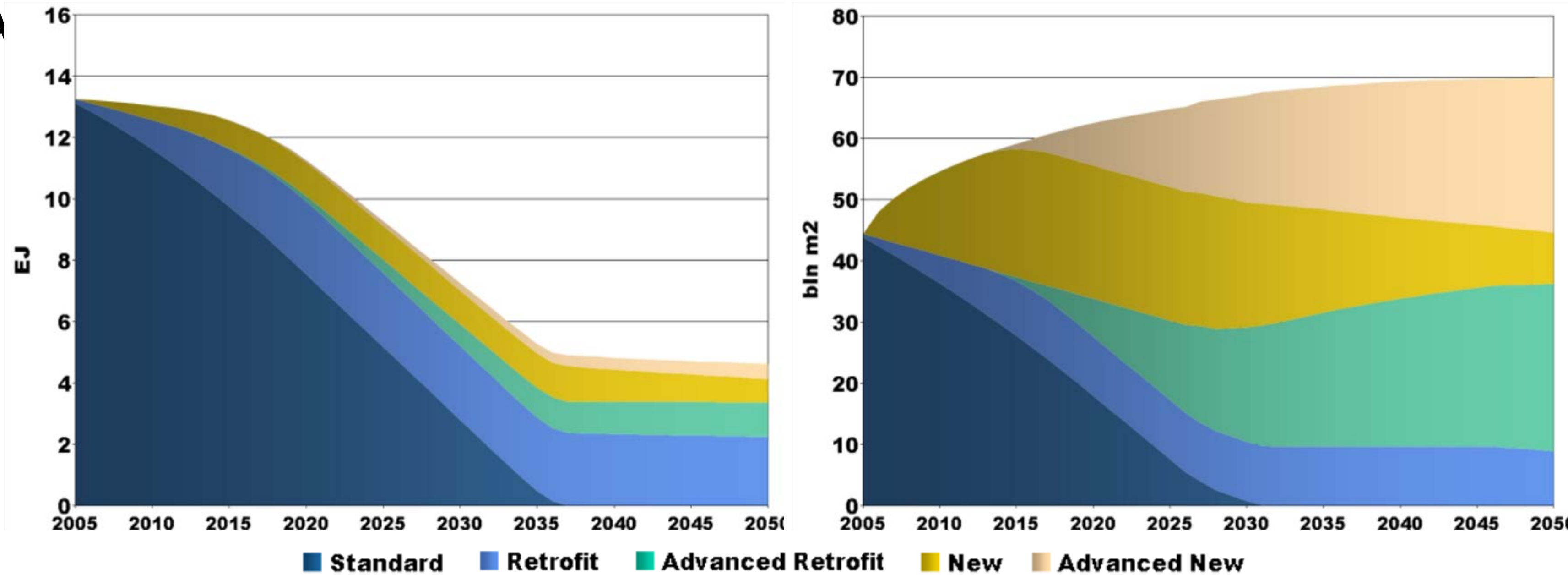
Source: Figure SPM.10, TS.15

Importance of building sector emissions

- In developed countries most future building emissions can be affected by retrofits….
- …while in developing countries through new construction.

Final Energy for SH&C and floor area by building vintage. Deep Efficiency Scenario

USA



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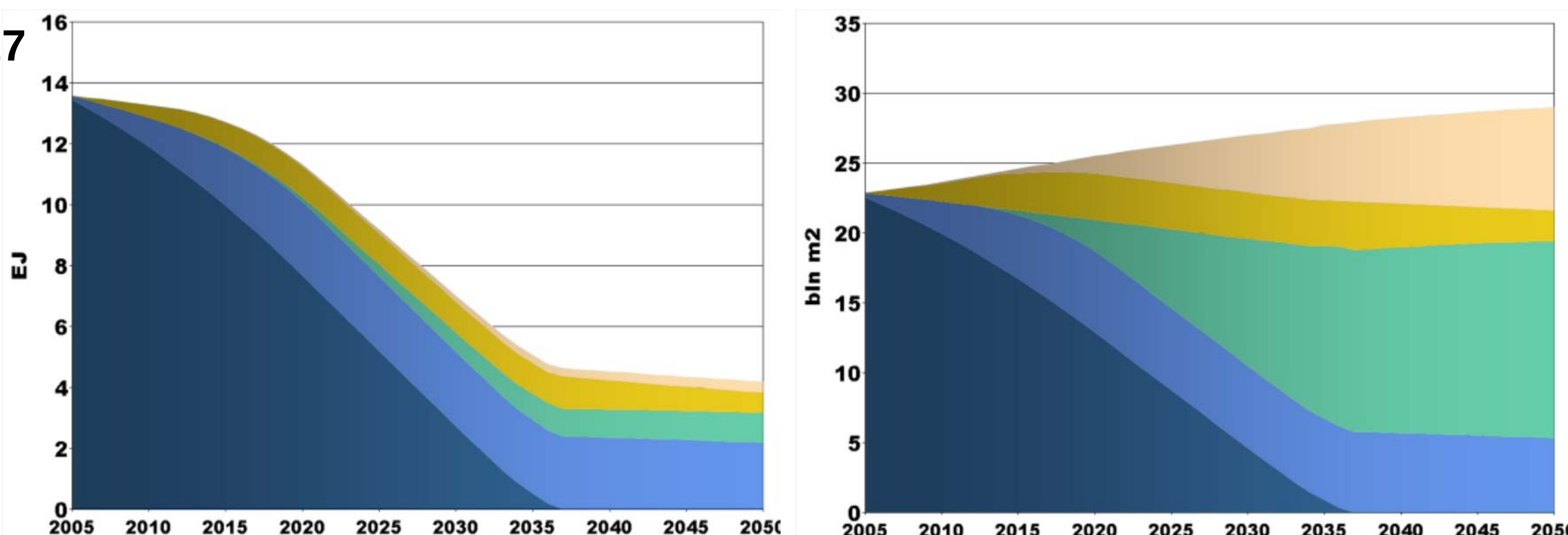

Lesson #2: importance of retrofits

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In developed countries, high-efficiency retrofits are the key to a low-emission building future; while in developing countries very high efficiency new buildings (cooling!!).

2. Efficient buildings have a very high mitigation potential

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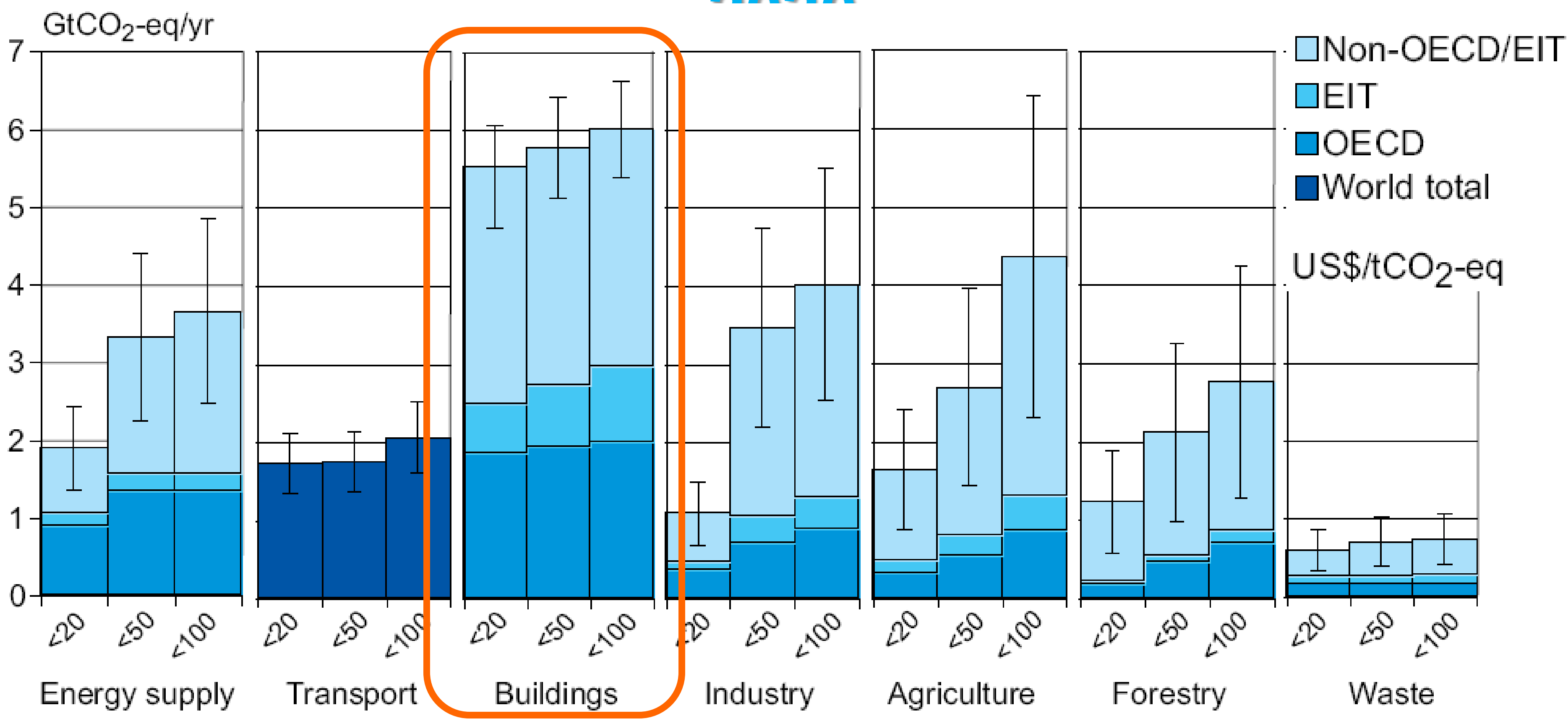
AR4: The buildings sector offers the largest low-cost potential in all world regions by



(potential at <US$100/ tCO_2-eq: 2.4 - 4.7 Gt CO_2-eq/yr)	*(potential at <US$100/ tCO_2-eq: 1.6 - 2.5 Gt CO_2-eq/yr)*	*(potential at <US$100/ tCO_2-eq: 5.3 -6.7 Gt CO_2-eq/yr)*	*(potential at <US$100/ tCO_2-eq: 2.5 - 5.5 Gt CO_2-eq/yr)*	*(potential at <US$100/ tCO_2-eq: 2.3 -6.4 Gt CO_2-eq/yr)*	*(potential at <US$100/ tCO_2-eq: 1.3 - 4.2 Gt CO_2-eq/yr)*	*(potential at <US$100/ tCO_2-eq: 0.4 - 1 Gt CO_2-eq/yr)*

Source: IPCC 2007, AR4, Chapter 10

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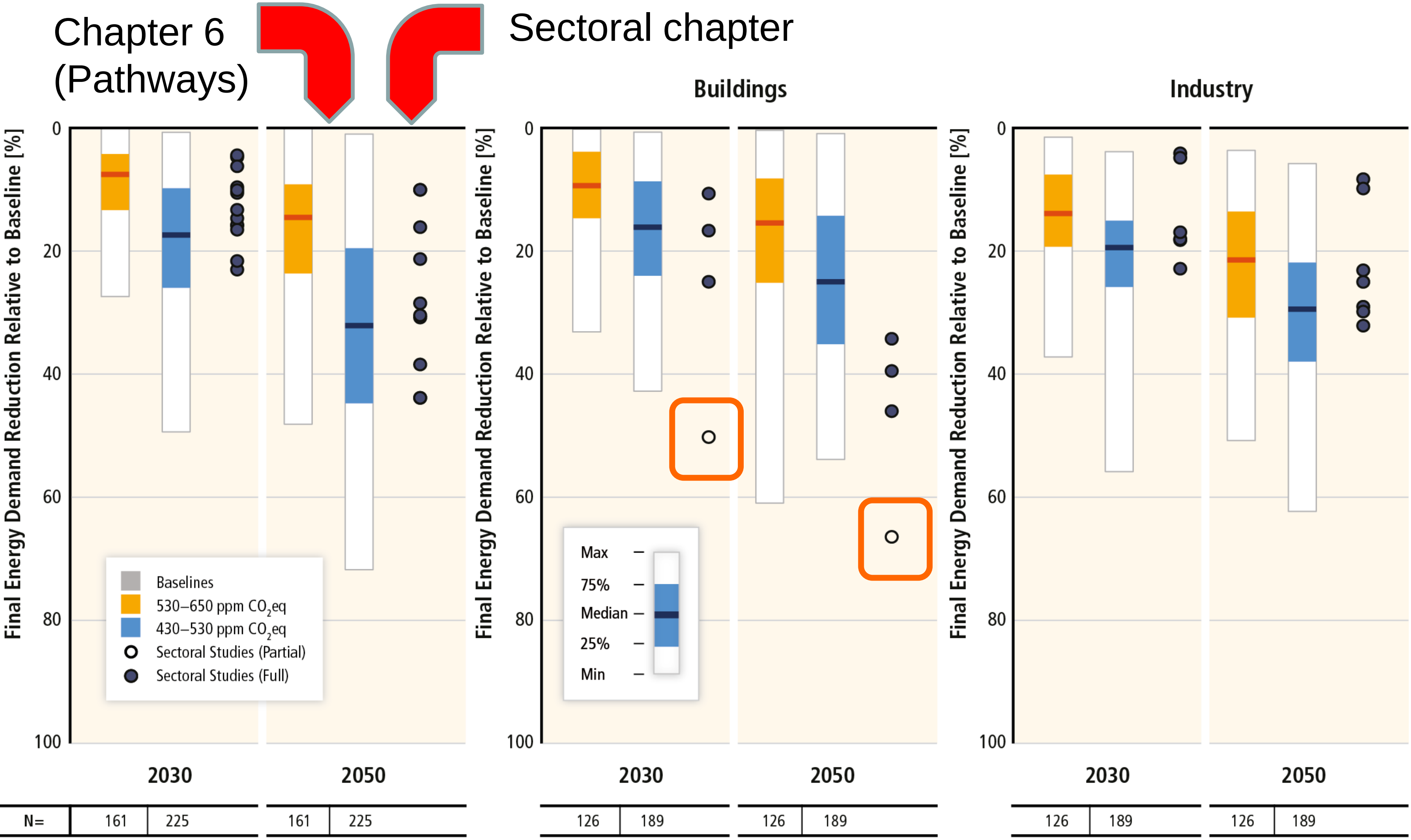
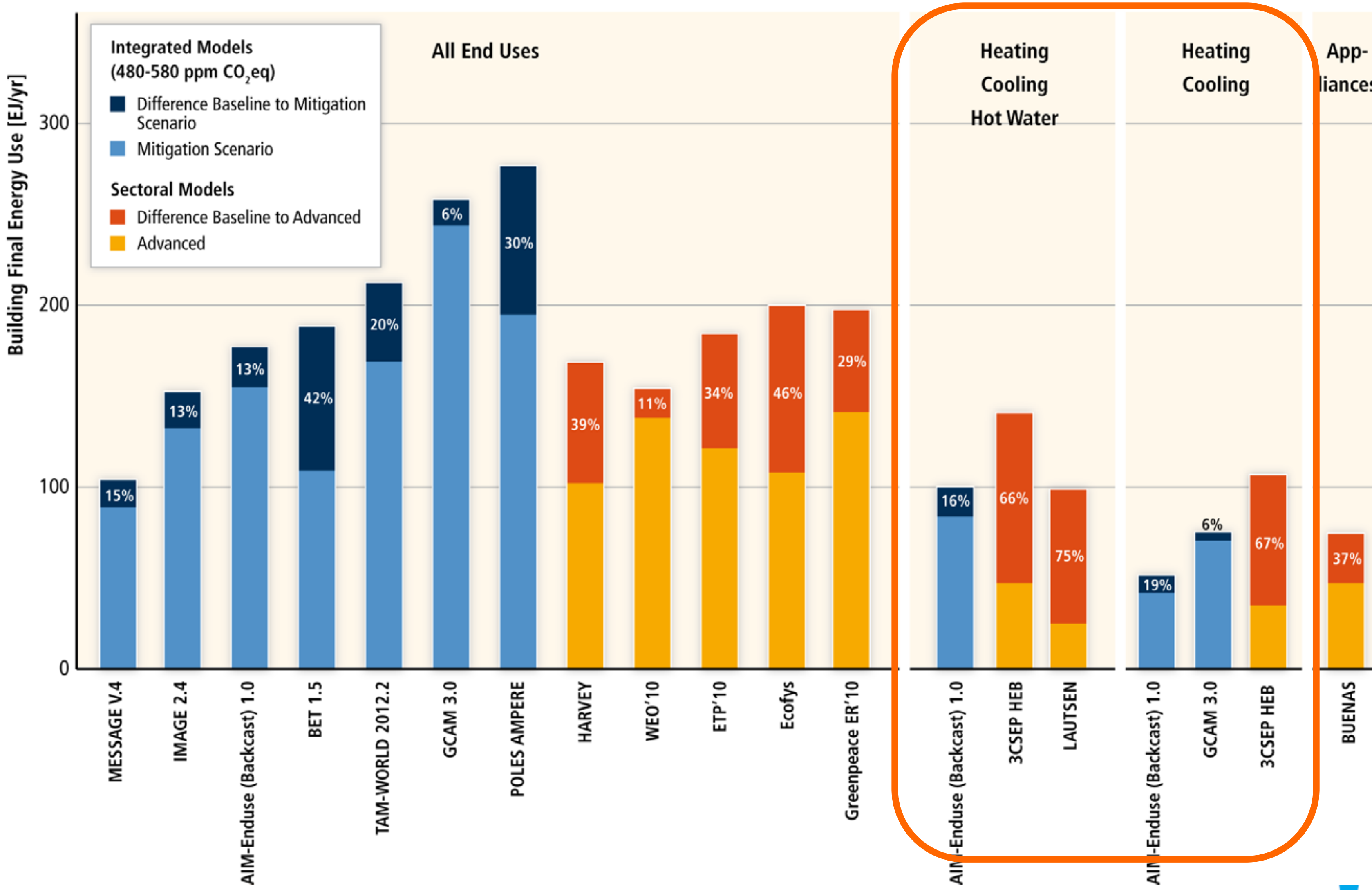
Energy Demand Reduction Potential



Source: Figure SPM.11

Thermal energy uses have the highest potential for energy use reductions in the building sector



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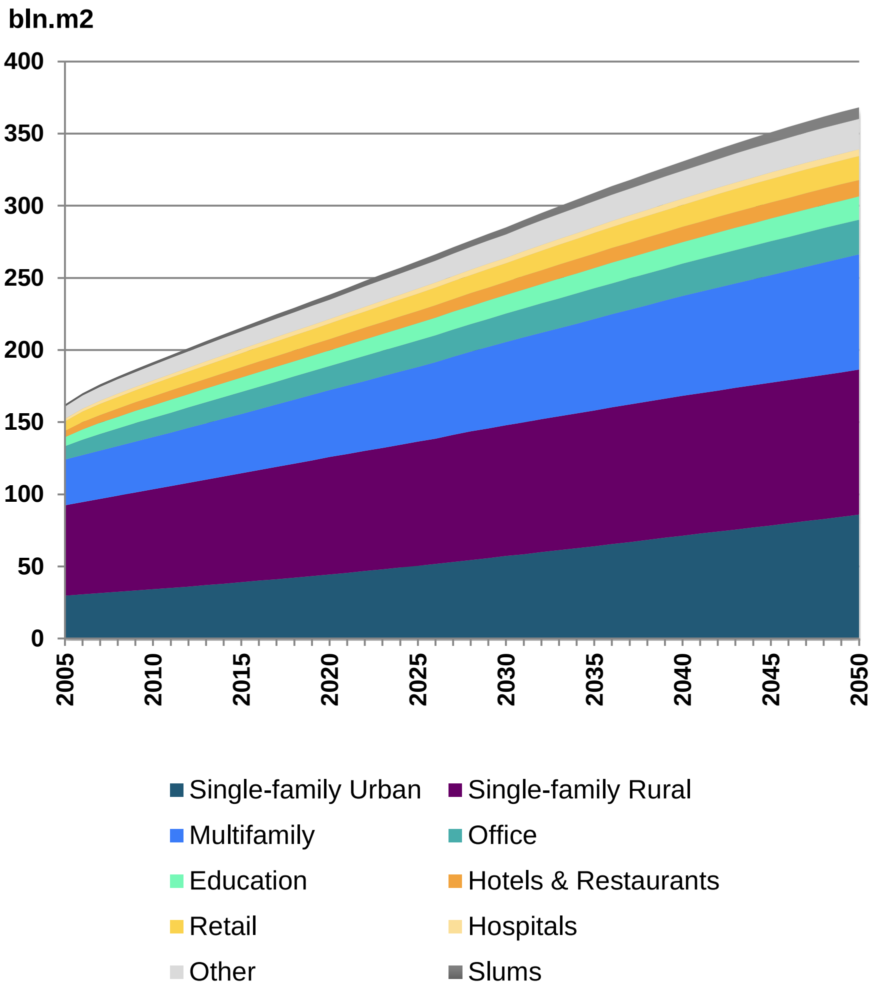
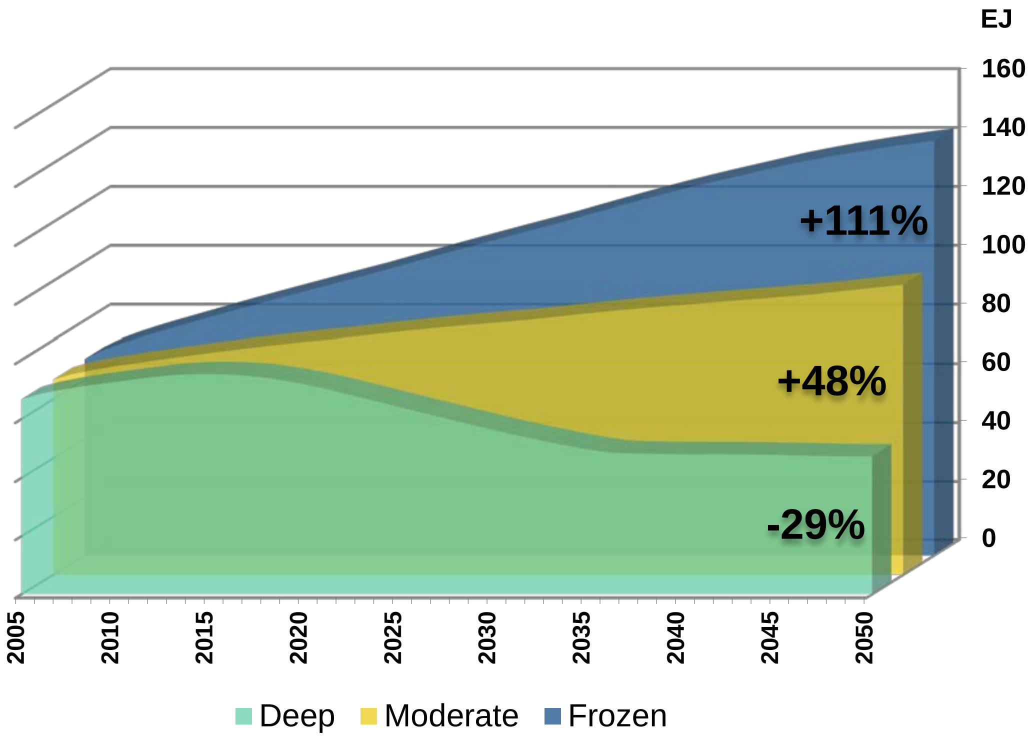
World floor area



World final thermal energy use



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3. They are among the most cost-effective options to mitigate CC

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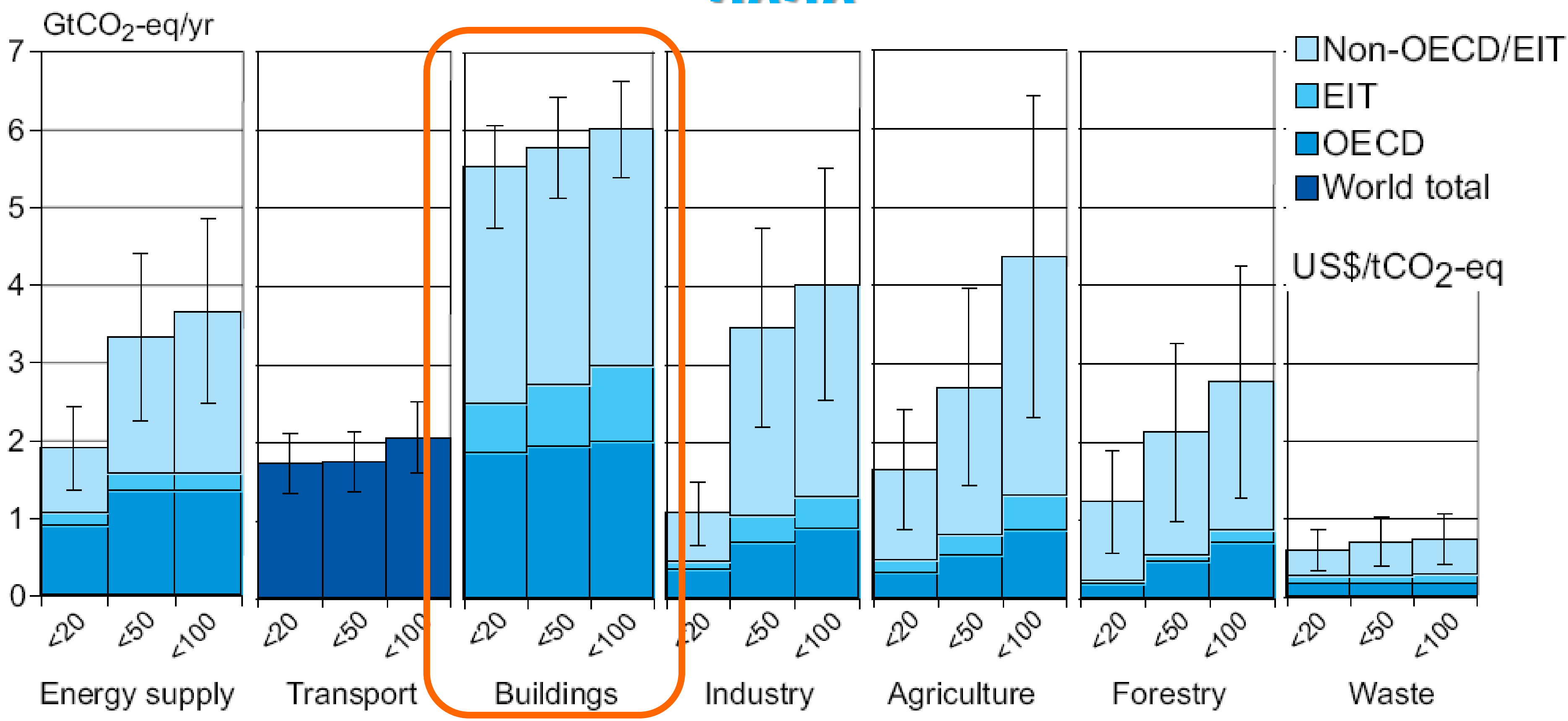
AR4: The buildings sector offers the largest low-cost potential in all world regions by 2030



(potential at <US$100/ tCO_2-eq: 2.4 - 4.7 Gt CO_2-eq/yr)	*(potential at <US$100/ tCO_2-eq: 1.6 - 2.5 Gt CO_2-eq/yr)*	*(potential at <US$100/ tCO_2-eq: 5.3 -6.7 Gt CO_2-eq/yr)*	*(potential at <US$100/ tCO_2-eq: 2.5 - 5.5 Gt CO_2-eq/yr)*	*(potential at <US$100/ tCO_2-eq: 2.3 -6.4 Gt CO_2-eq/yr)*	*(potential at <US$100/ tCO_2-eq: 1.3 - 4.2 Gt CO_2-eq/yr)*	*(potential at <US$100/ tCO_2-eq: 0.4 - 1 Gt CO_2-eq/yr)*

Source: IPCC 2007, AR4, Chapter 10

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Lesson #4: DURABILITY

Durability of (energy-efficient) buildings and their components are crucial in determining their mitigation cost-effectiveness;

as well as improve their mitigation potential due to reduced embodied emissions

Figure 9.14. Cost of conserved energy as a function of energy performance improvement (kWh/m2/yr difference to baseline) to reach 'Passive House' or more stringent performance levels, for new construction by different building types and climate zones in Europe

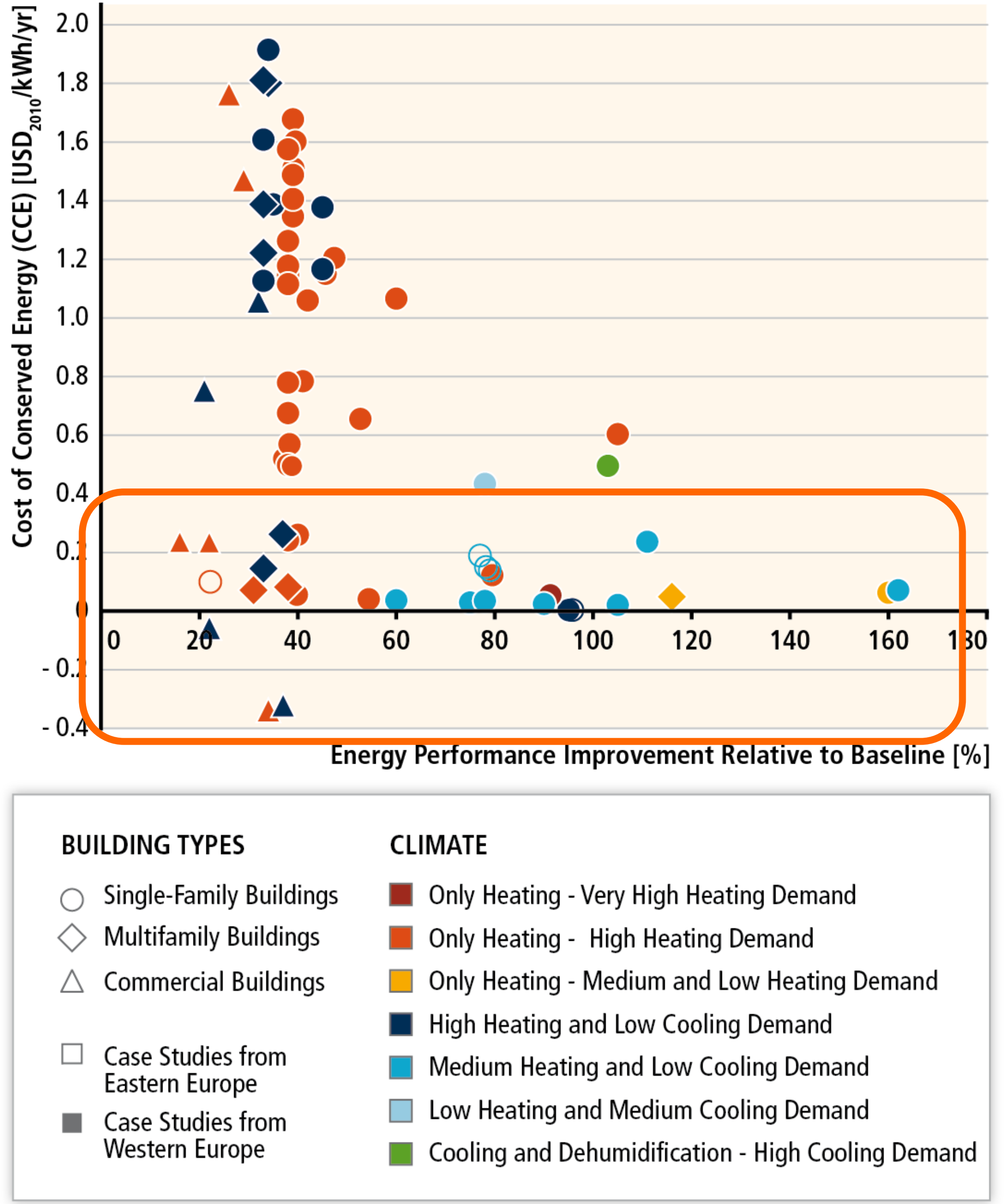


Figure 9.15. Cost of conserved carbon as a function of specific energy consumption for selected best practices shown in Figure 9.14.

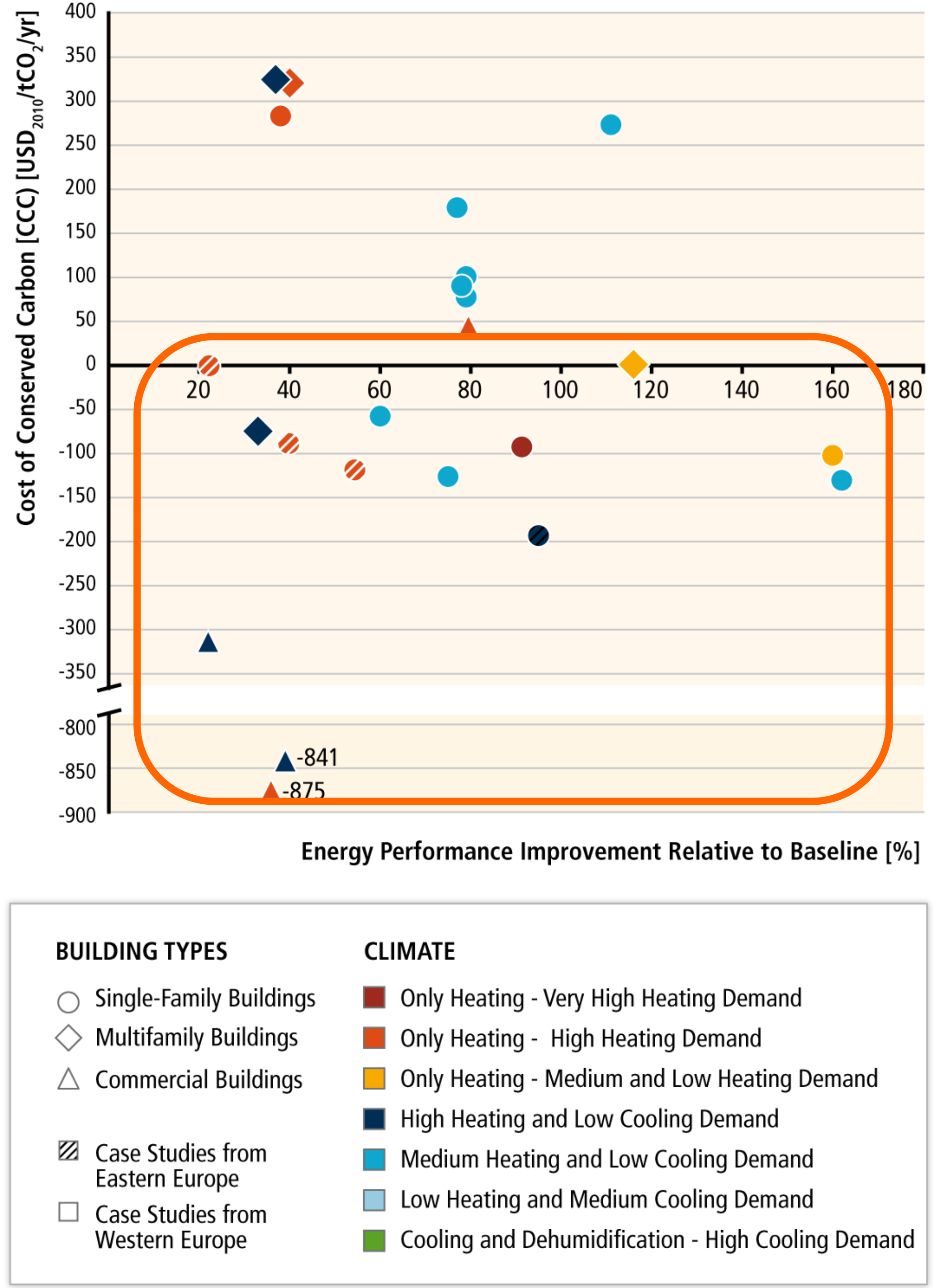
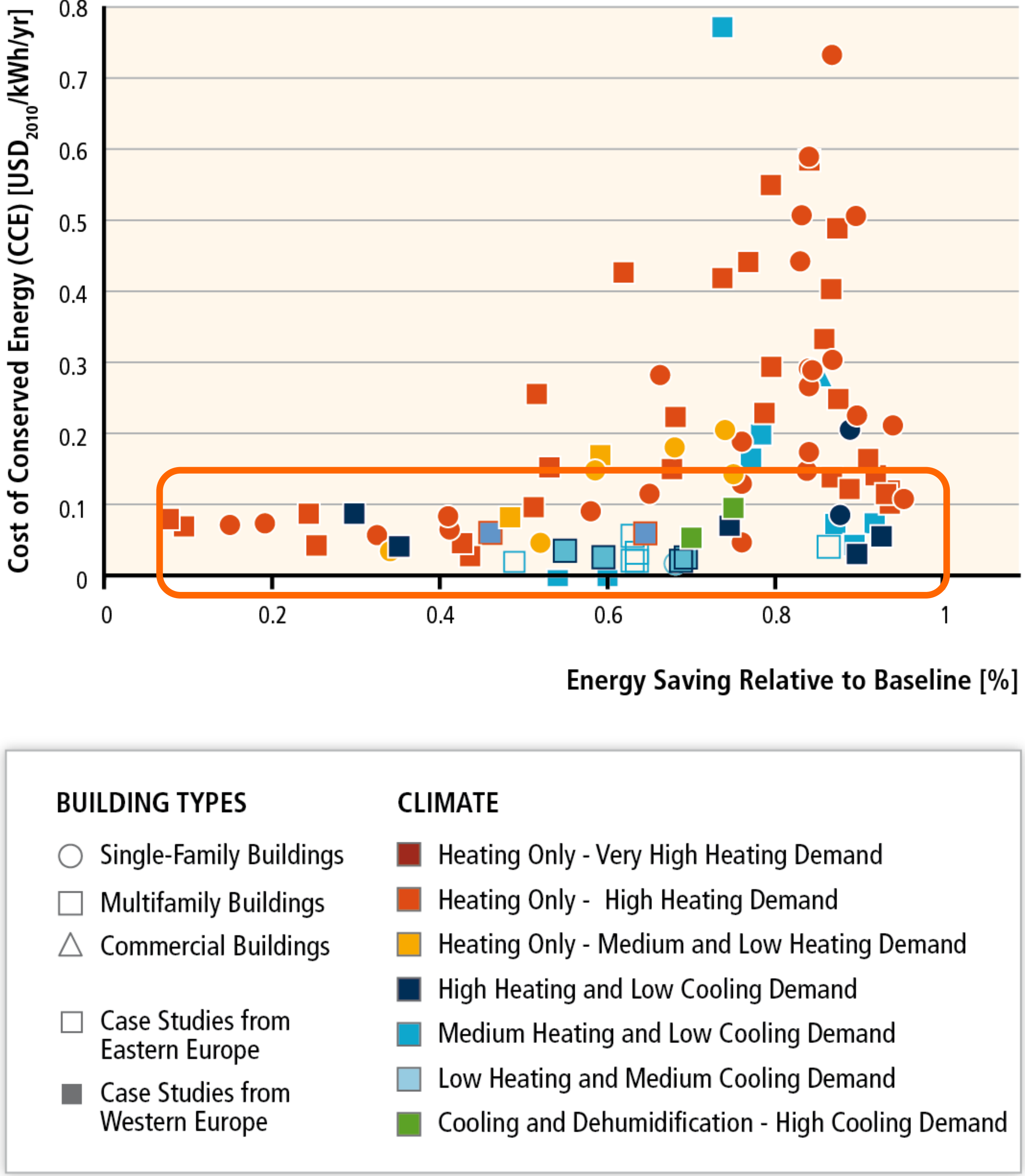


Figure 9.16. Cost of conserved energy as a function of energy saving in percent for European retrofitted buildings by building type and climate zones.



4. In addition, they have high co-benefits

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"Overall, the potential for co-benefits for energy end-use measures outweigh the potential for adverse side-effects, whereas the evidence suggests this may not be the case for all energy supply and AFOLU measures." (SPM 4.1)

Co-benefits and adverse side-effects of energy-efficient buildings

Buildings	/concerns		additional objectives/(
	Environmental	Other	cial
			ee Table TS.3.
Fuel switching, RES incorporation, green roofs, and other measures reducing emissions intensity	Health impact in residential buildings via ↓ Outdoor air pollution (r/h) ↓ Indoor air pollution (in DCs) (r/h) ↓ Fuel poverty (r/h) ↓ Ecosystem impact (less outdoor air pollution) (r/h) ↑ Urban biodiversity (for green roofs) (m/m)	Reduced Urban Heat Island Effect (UHI) (l/m)	) via energy cost) (l/m) ien/children cookstoves) (m/h)
Retrofits of existing buildings (e.g., cool roof, passive solar, etc.) Exemplary new buildings Efficient equipment	Health impact via ↓ Outdoor air pollution (r/h) ↓ Indoor air pollution (for efficient cookstoves) (r/h) ↓ Indoor environmental conditions (m/h) ↓ Fuel poverty (r/h) ↓ Insufficient ventilation (m/m) ↓ Ecosystem impact (less outdoor air pollution) (r/h) ↓ Water consumption and sewage production (l/l)	Reduced UHI (retrofits and new exemplary buildings) (l/m)	s, efficient equipment) (m/h) st for housing due to the m) rofits and exemplary new ien and children cookstoves) (m/h)
Behavioural changes reducing energy demand	↓ Health impact via less outdoor air pollution (r/h) & improved indoor environmental conditions (m/h) ↓ Ecosystem impact (less outdoor air pollution) (r/h)		

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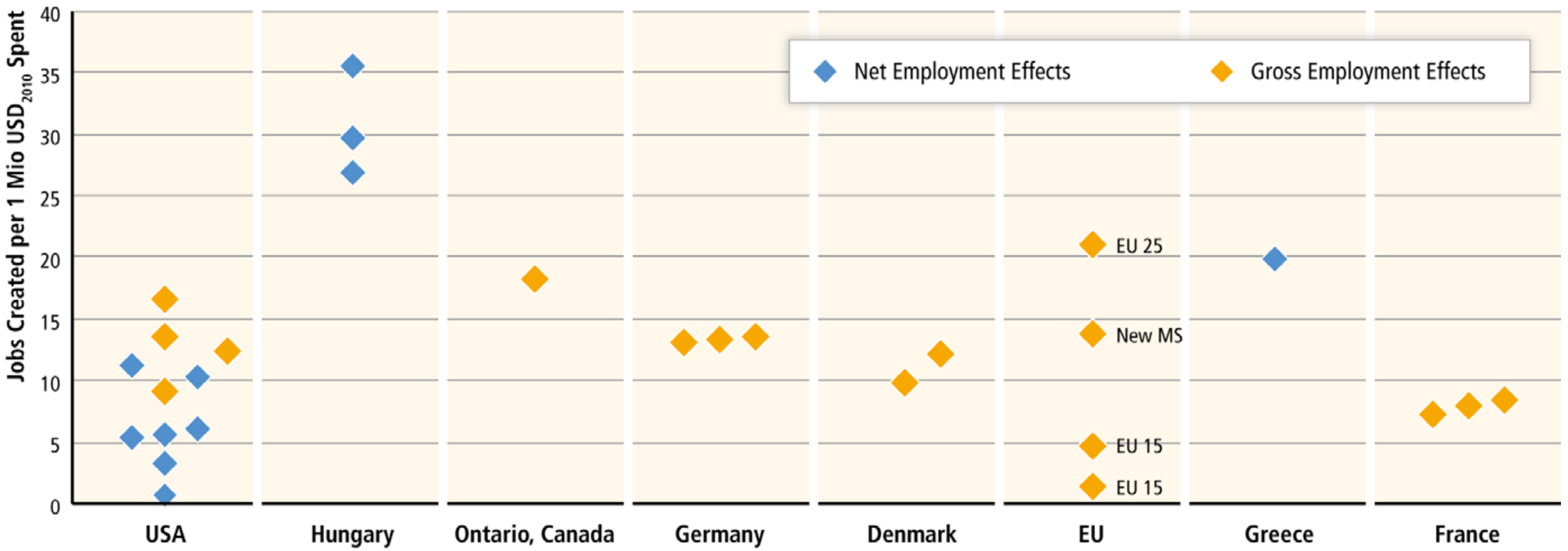
Studies on employment effects due to improved building energy efficiency



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Further co-benefits, details

- monetizable co-benefits alone are at least twice the resulting operating cost savings.
- Energy efficient buildings may result in increased productivity by 1–9% or even higher.
- Productivity gains can rank among the highest value co-benefits when these are monetized, esp. in countries with high labour costs
- Significant potential energy security gains:
  - e.g. a CEU study found that deep retrofitting the Hungarian building stock can save 39% of natural gas imports, and up to 59% of January imports (when most vulnerable to supply disruptions)

While opportunities are great, there is also a substantial lock-in risk

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"Infrastructure developments and long-lived products that lock societies into GHG-intensive emissions pathways may be difficult or very costly to change, reinforcing the importance of early action for ambitious mitigation" (SPM 4.2)

Lesson #4: need to go for the highest-tech

Building efficiency programs and policies need to encourage only the highest achievable efficiency levels. Shallow retrofits need to be avoided. It is better to "wait out" the opportunities for a deep, systemic retrofit rather engage in a shallow one. Most countries would need to revisit their support schemes and policies around retrofit!

Summary of lessons relevant for the PH community 1.

- External communication needs to improve
  - reporting achievements, costs, penetration to other communities
  - e.g. the academic literature
- Much stronger focus on very deep retrofits are needed in developed countries (as opposed to just new)
- in other areas, preventing the need for mechanical cooling is essential.
- Bringing down the costs of deep retrofits through experience is crucial

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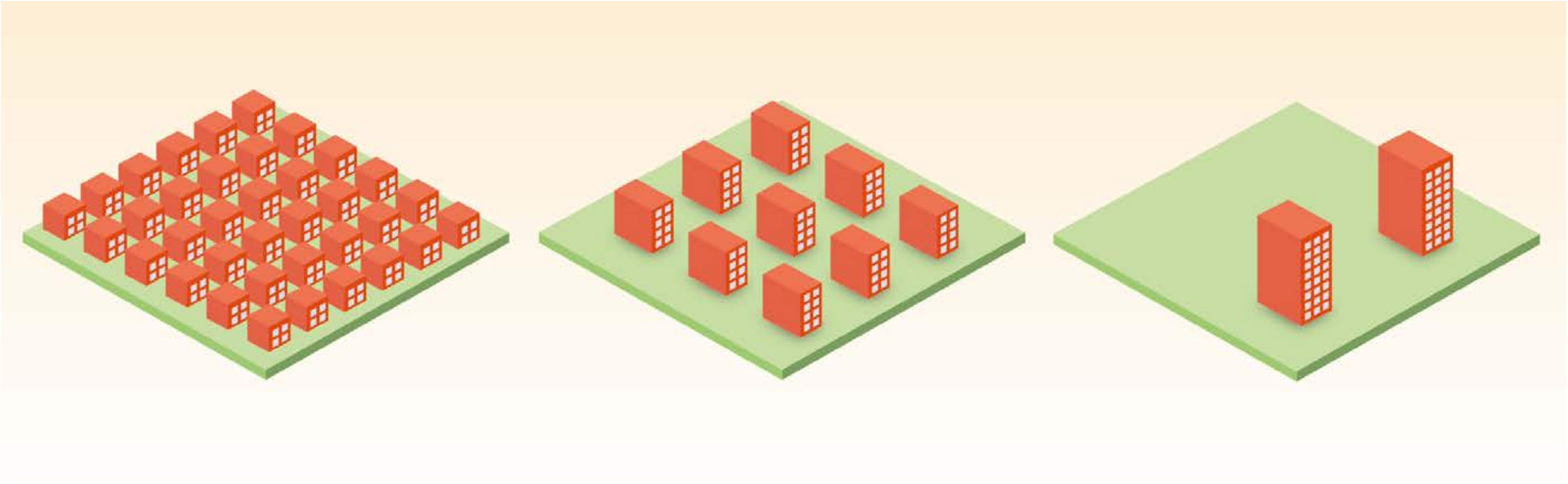
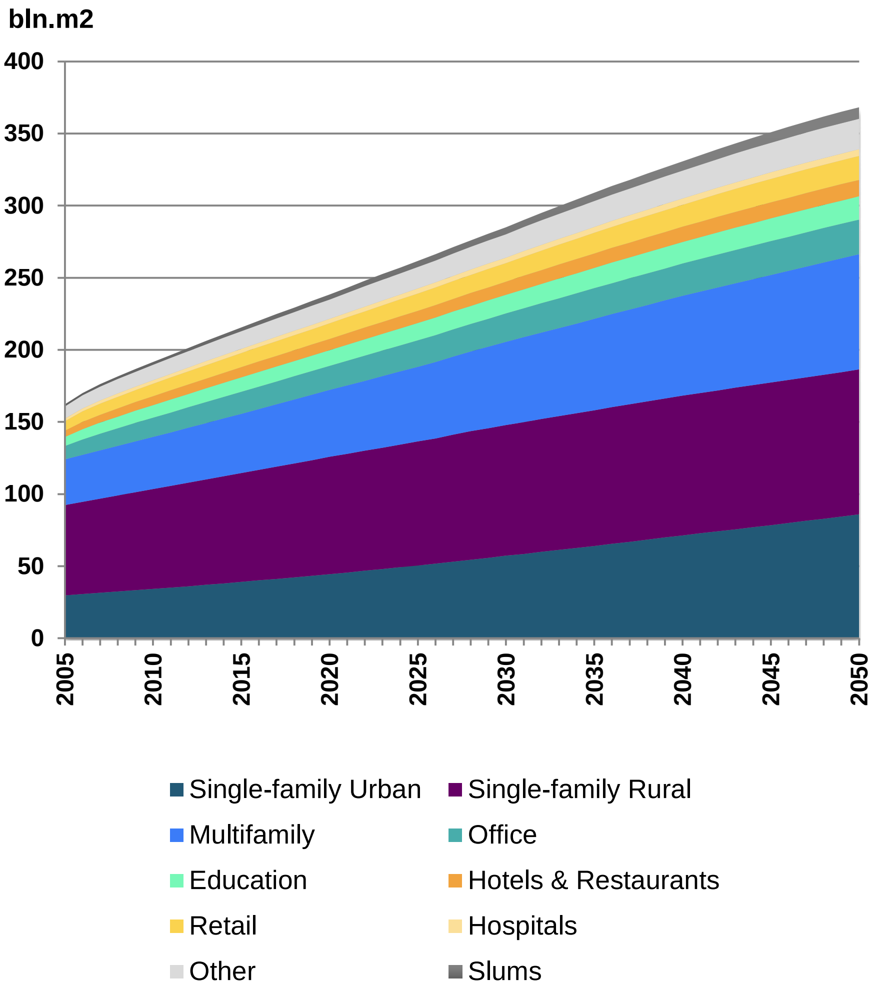
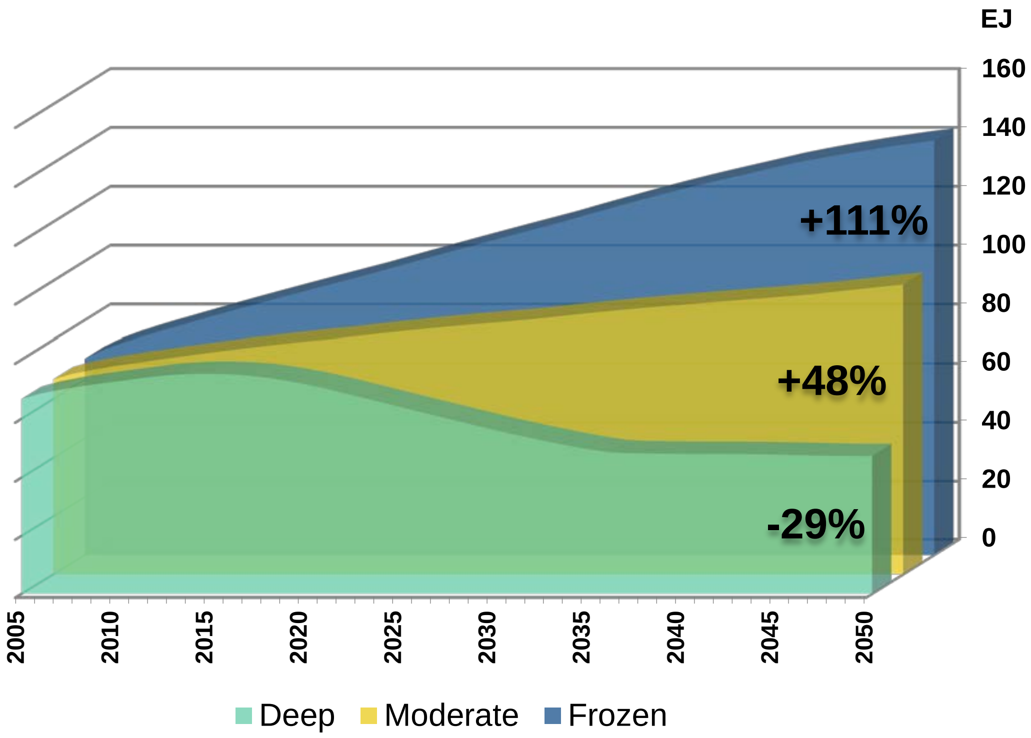
Increasing urban density is a necessary but not sufficient condition for lowering urban emissions



World floor area



World final thermal energy use



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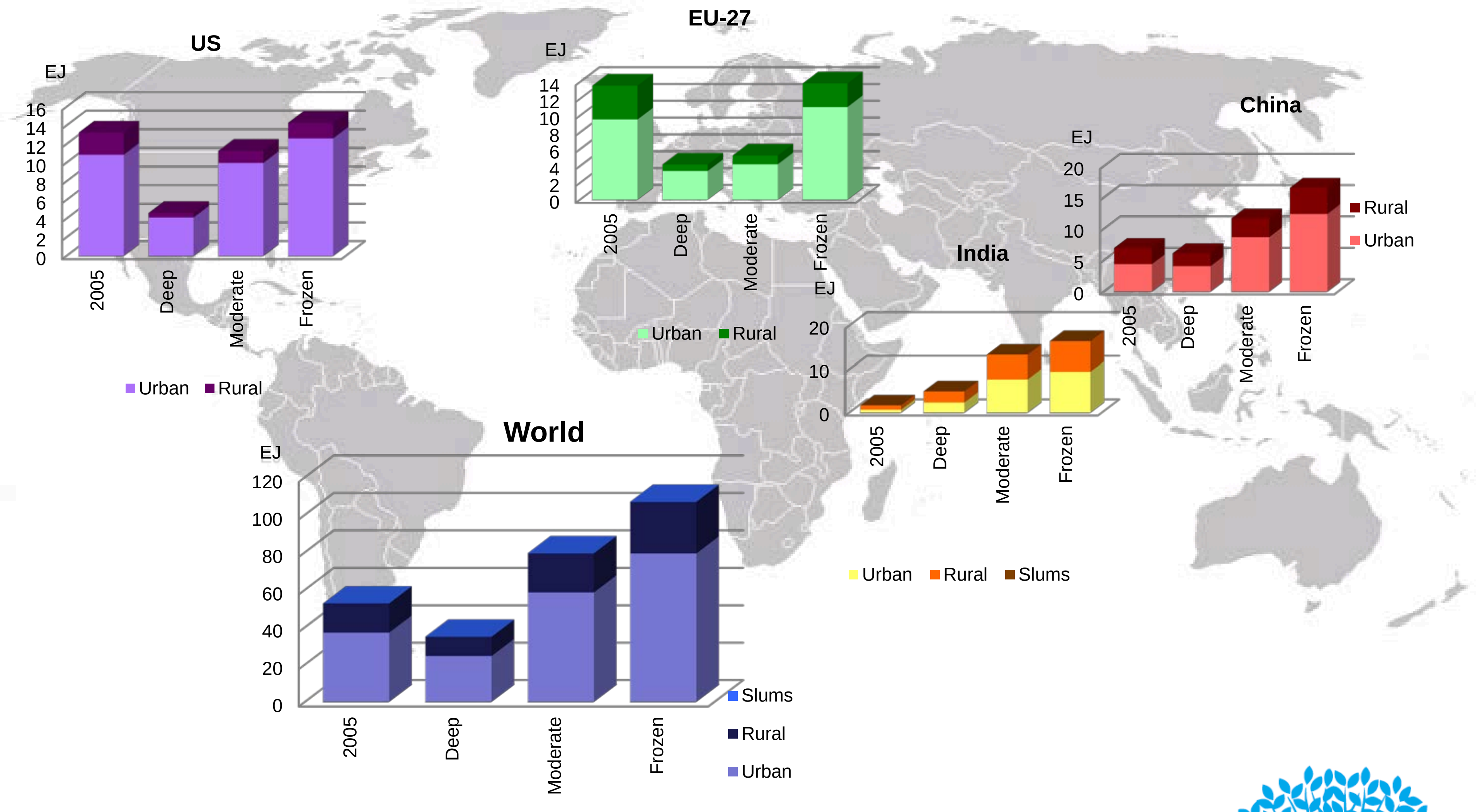
Urban vs. Rural Energy Use



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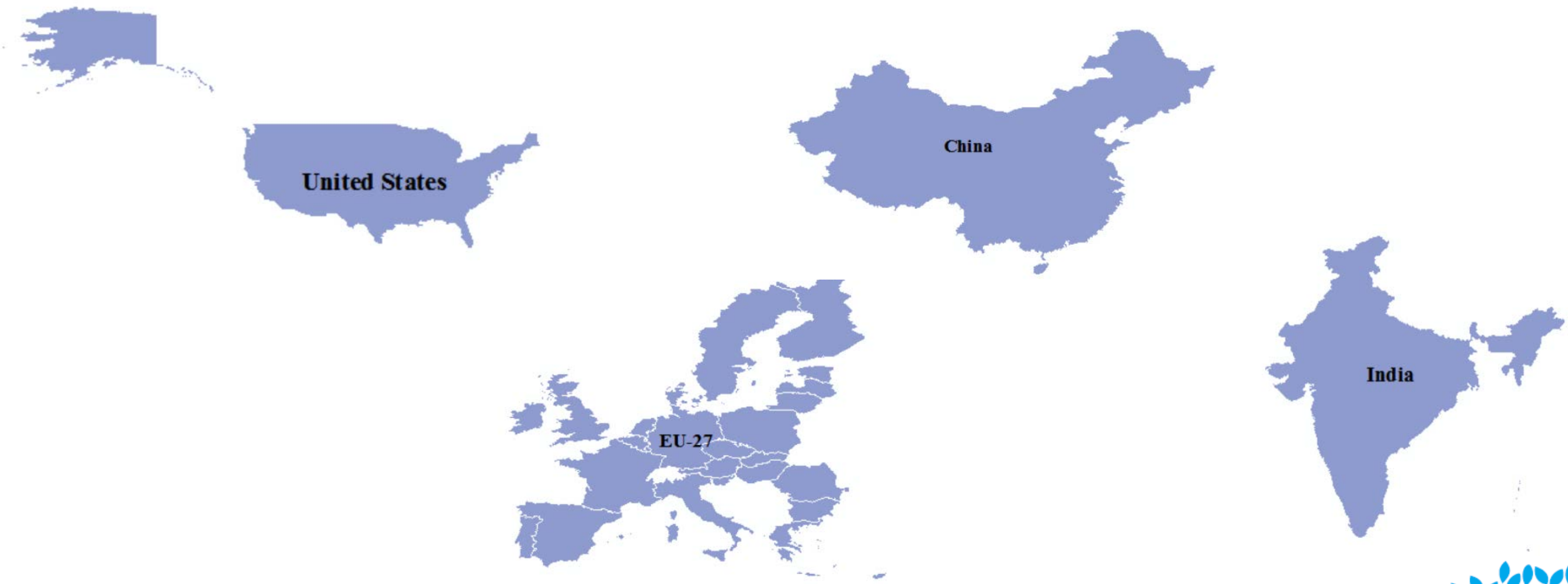
Regions



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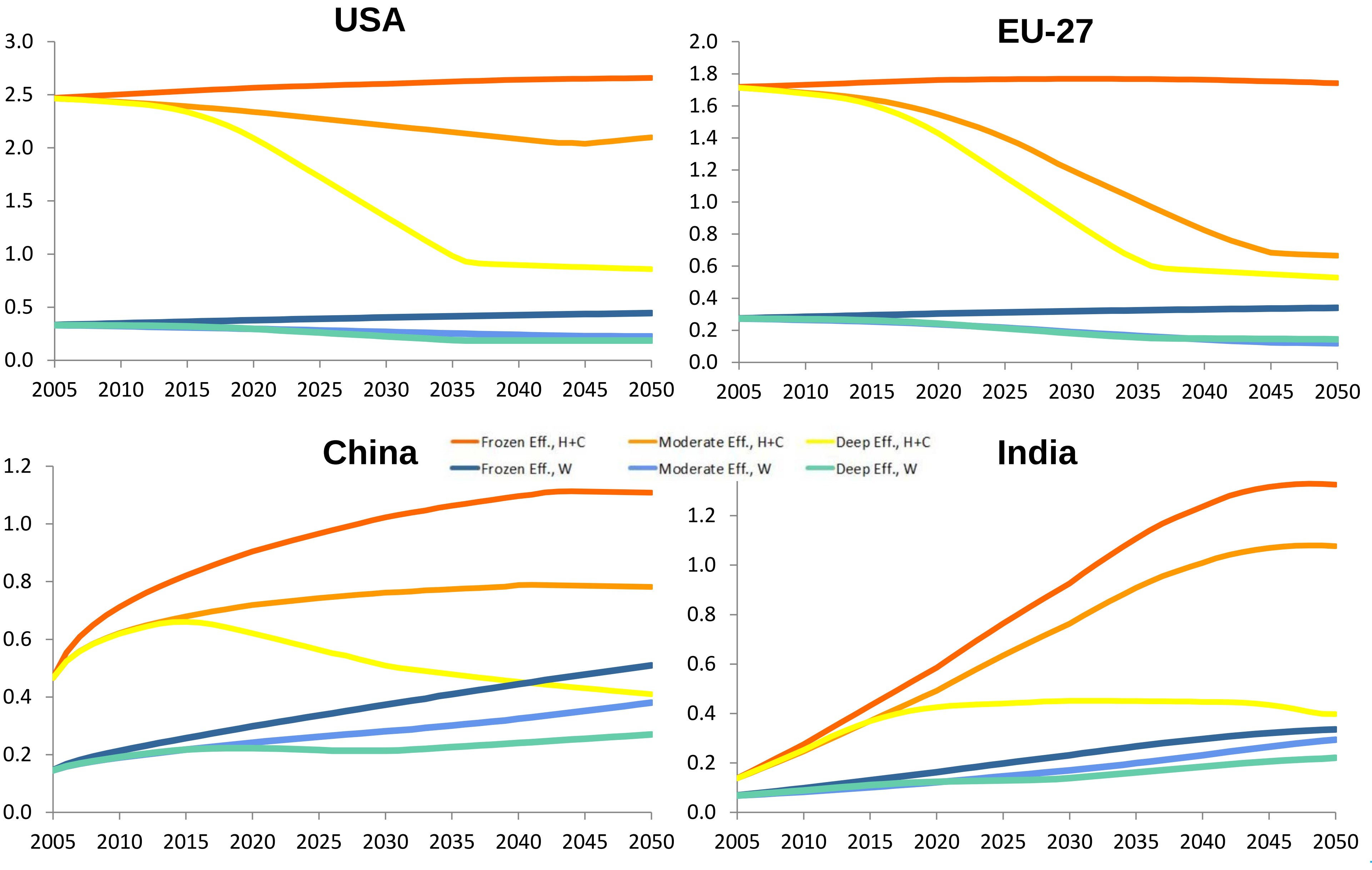
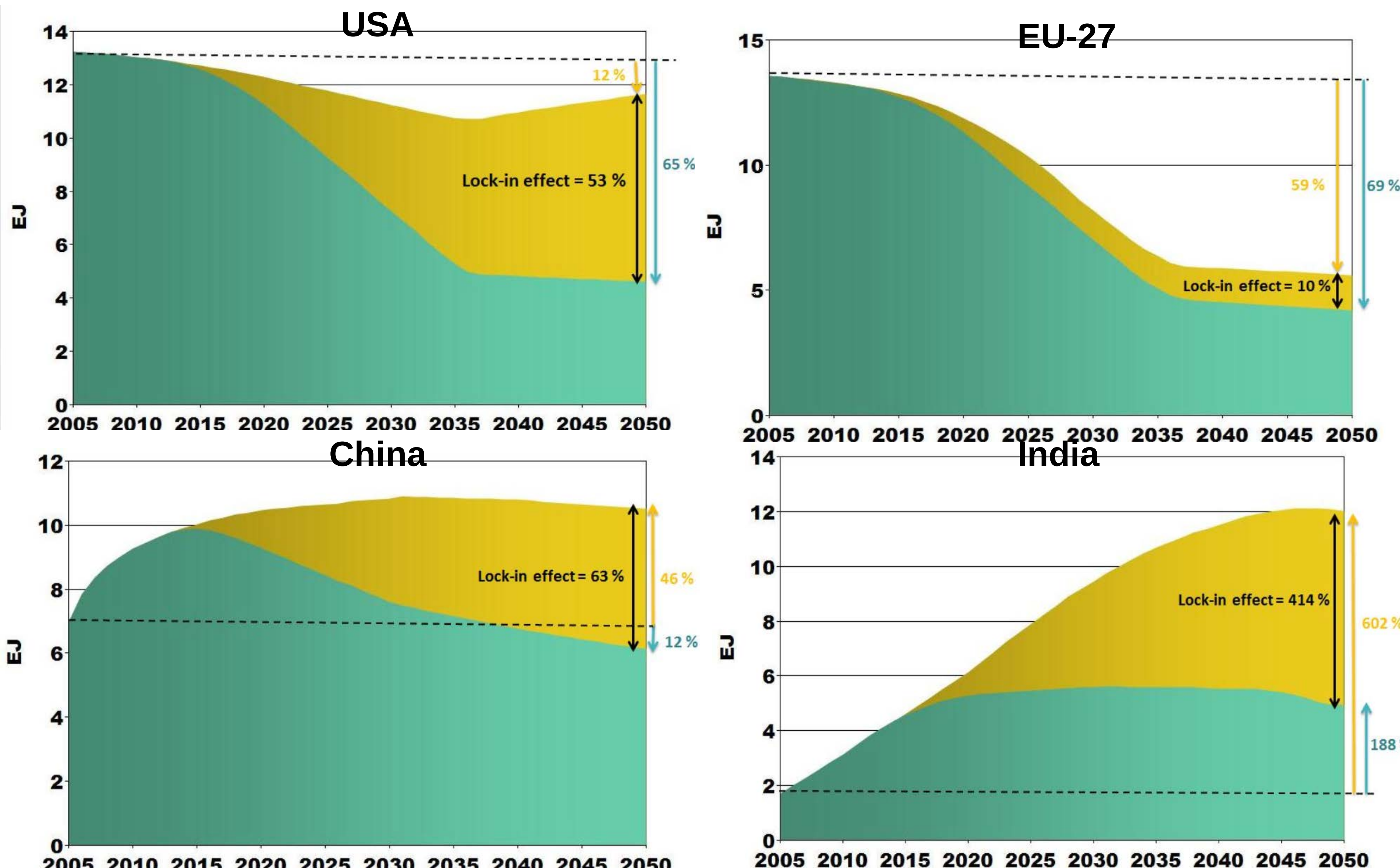
CO2 emissions

from space heating & cooling and water heating for key regions for all scenarios, GtCO2



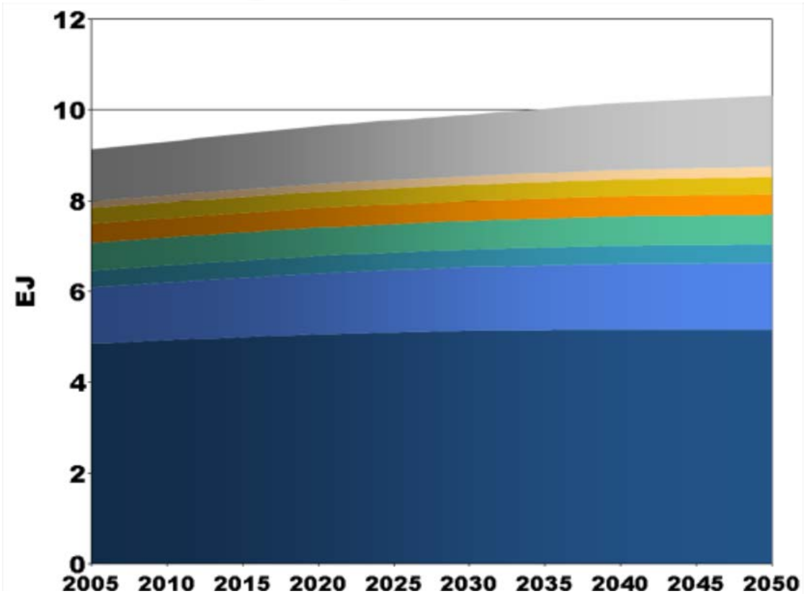
Lock-in Effect

from space heating & cooling for Moderate Efficiency and Deep Efficiency scenarios for key regions

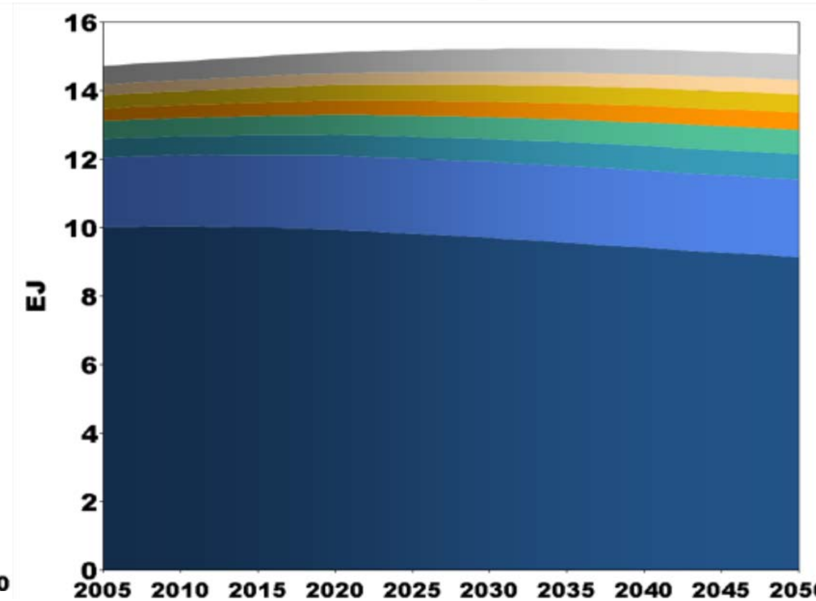


Final energy for space heating and cooling by building type in Frozen Efficiency Scenario

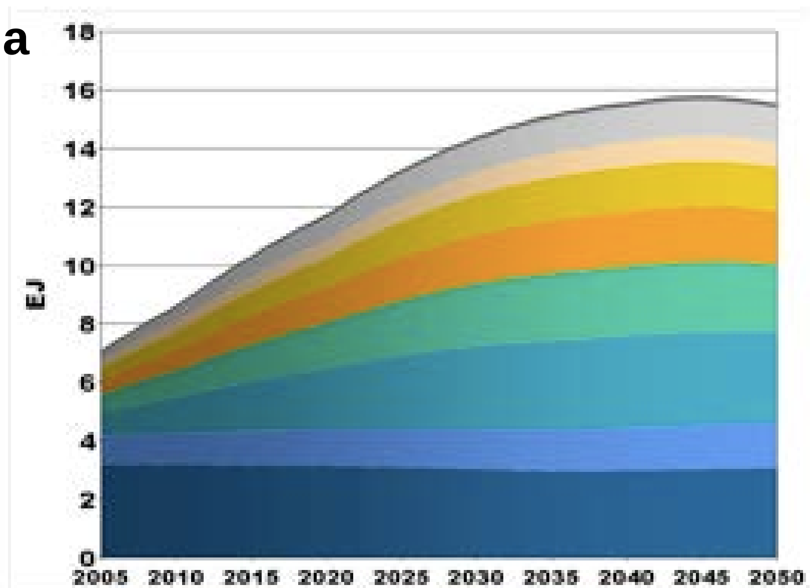
USA



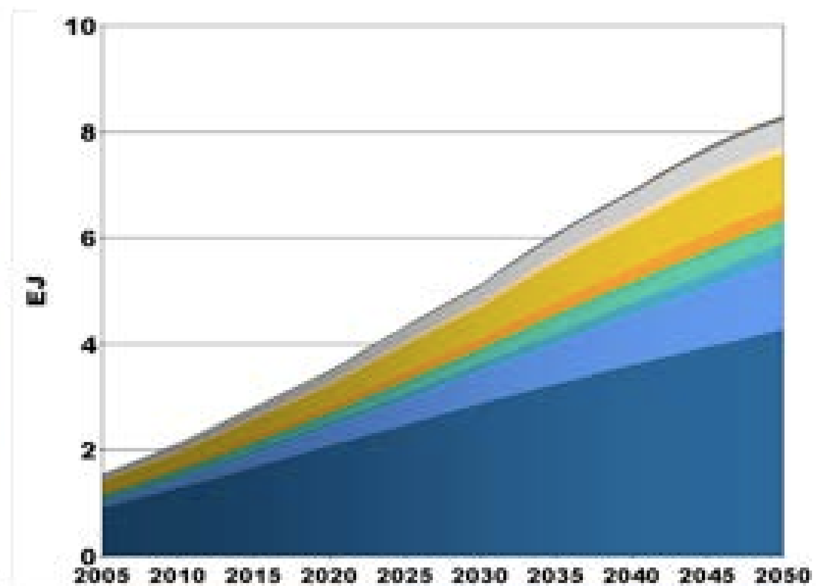
EU-27



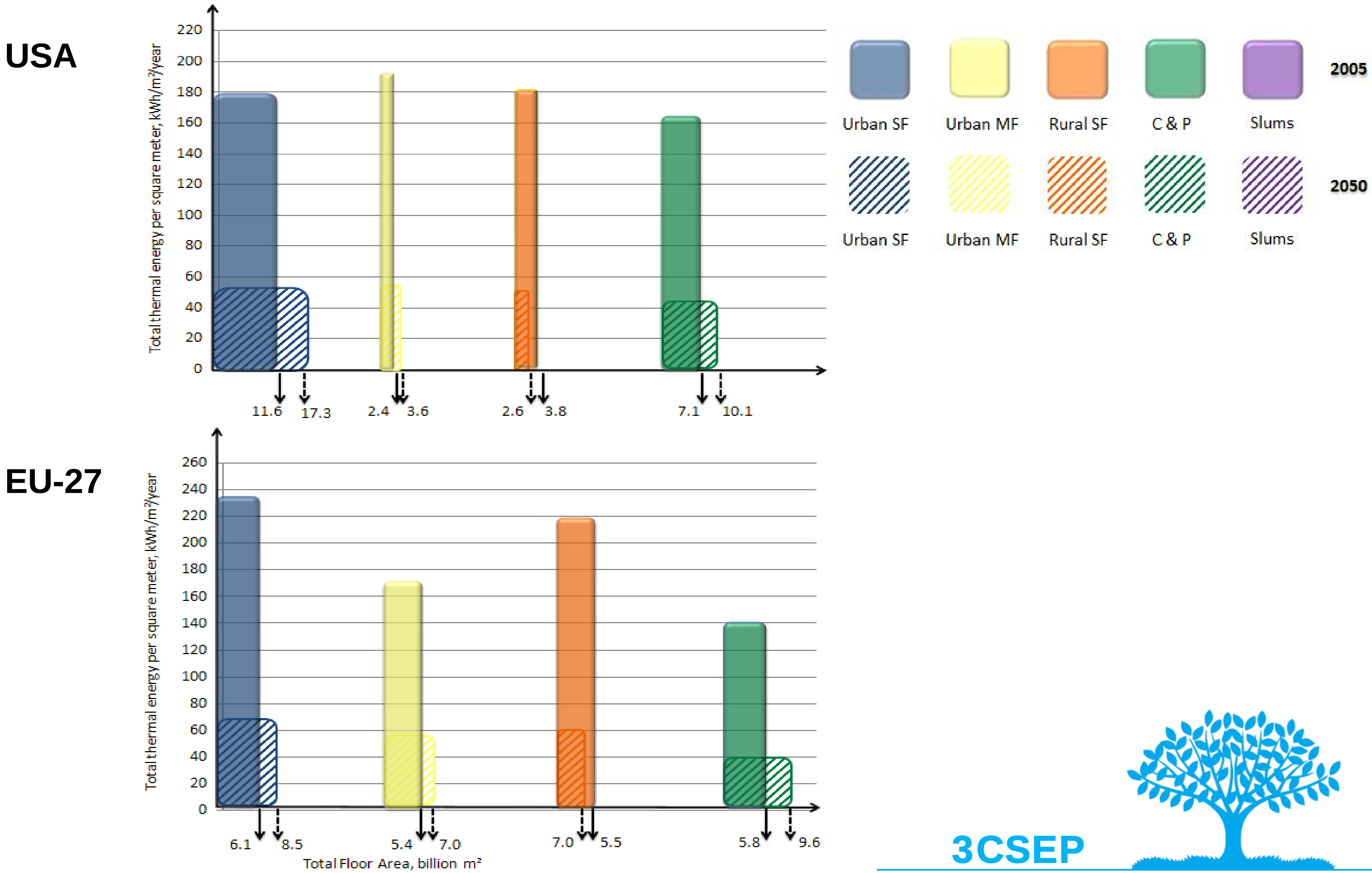
China



India



Final energy mitigation potential for Deep Efficiency scenario between 2005 and 2050



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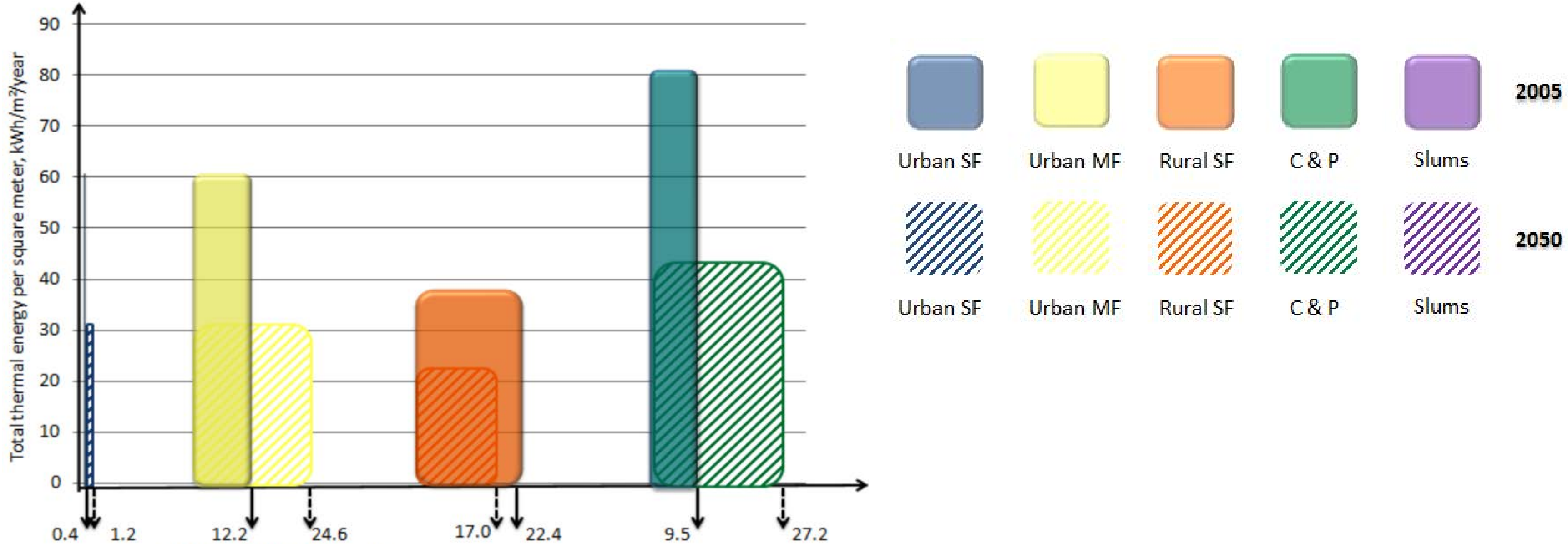
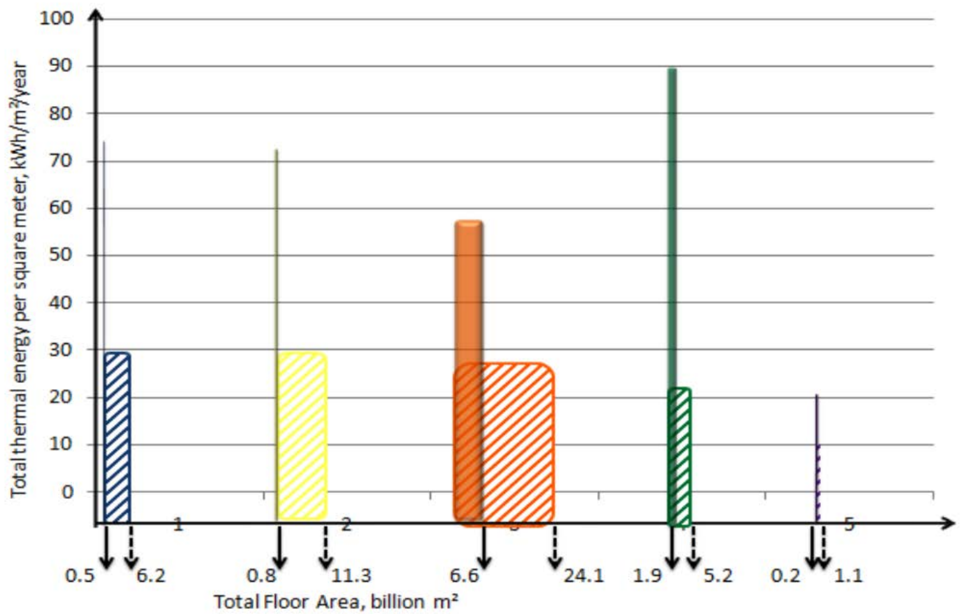
Final energy mitigation potential for Deep Efficiency scenario between 2005 and 2050

China



India



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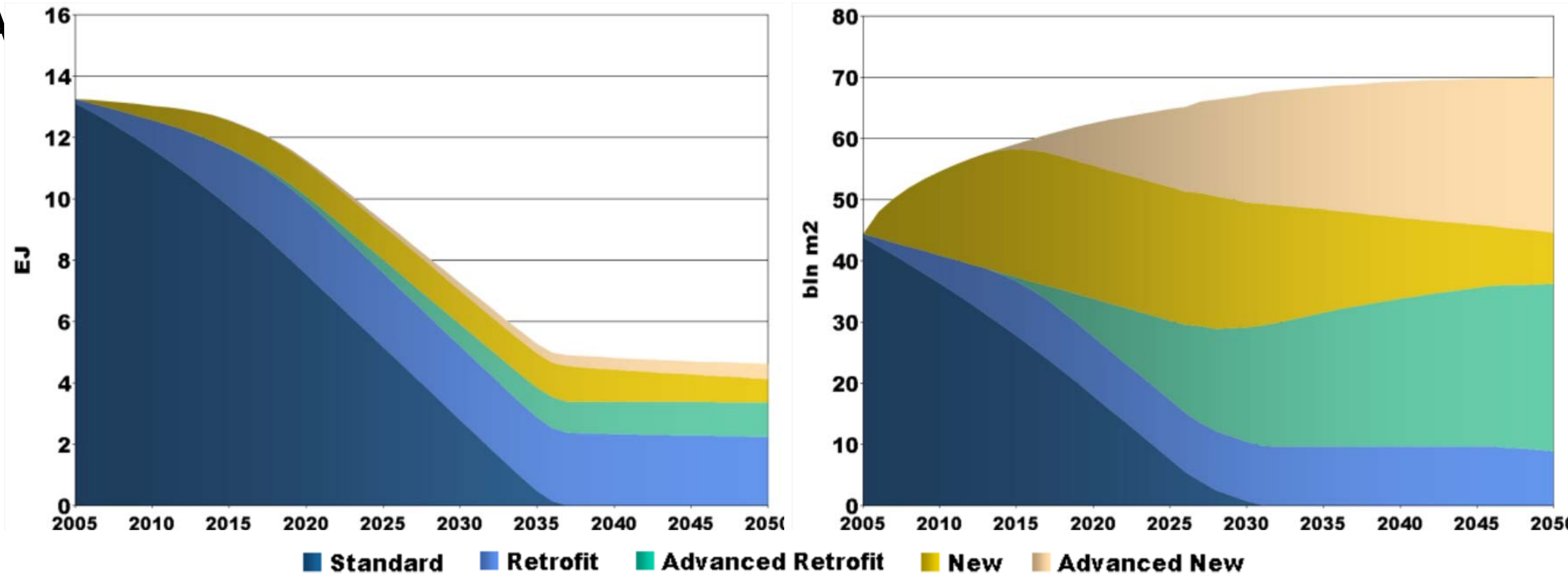
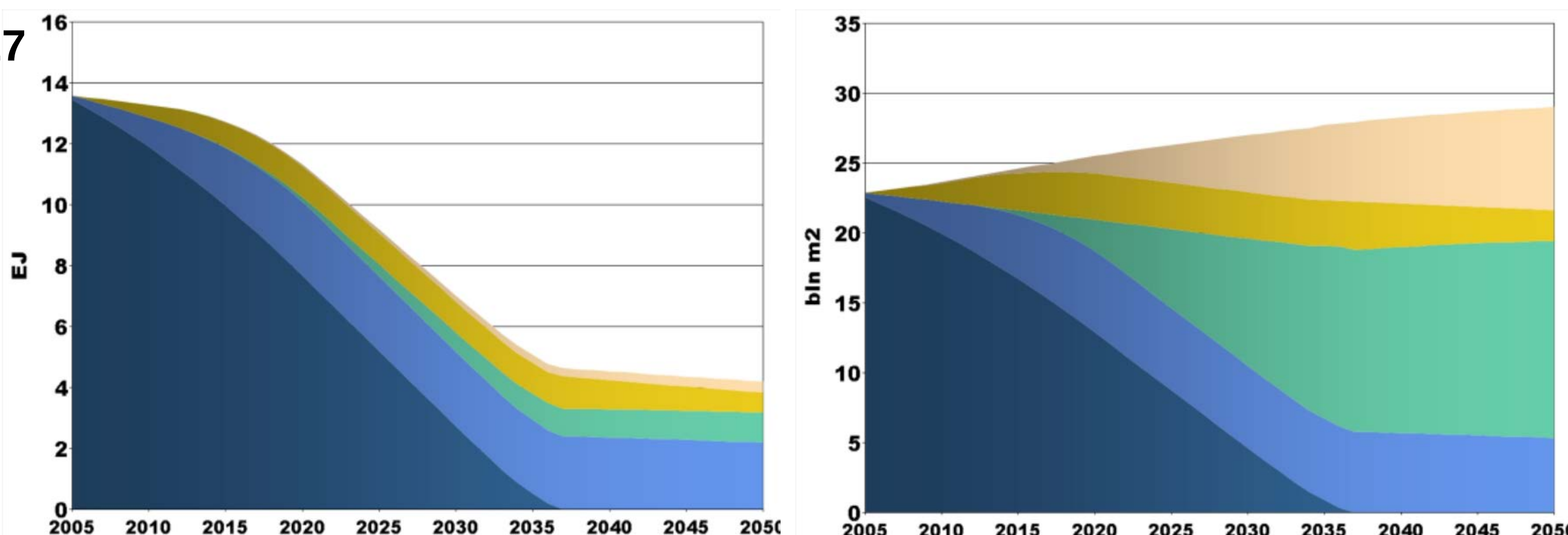
Final Energy for SH&C and floor area by building vintage. Deep Efficiency Scenario

USA



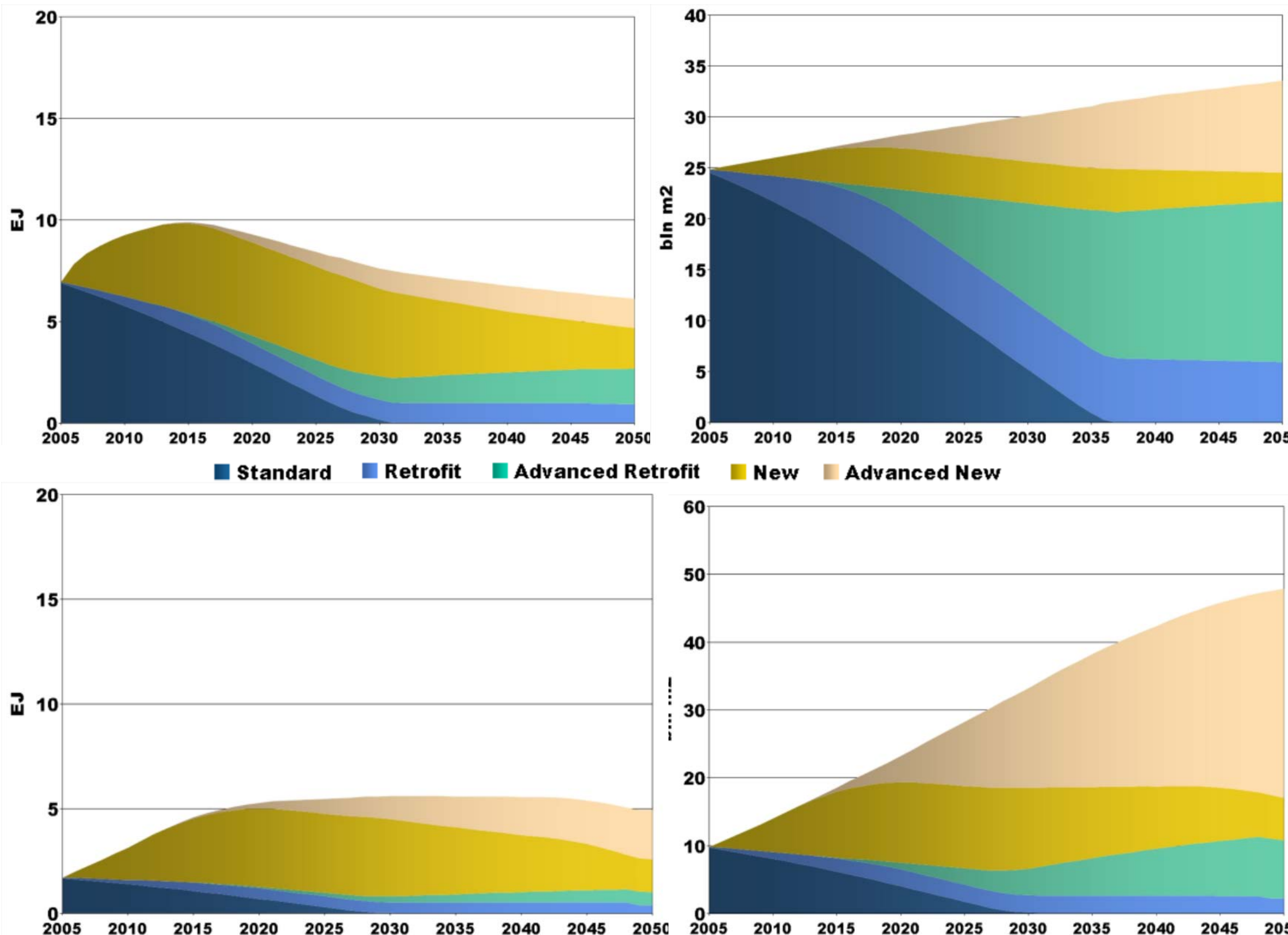
EU-27



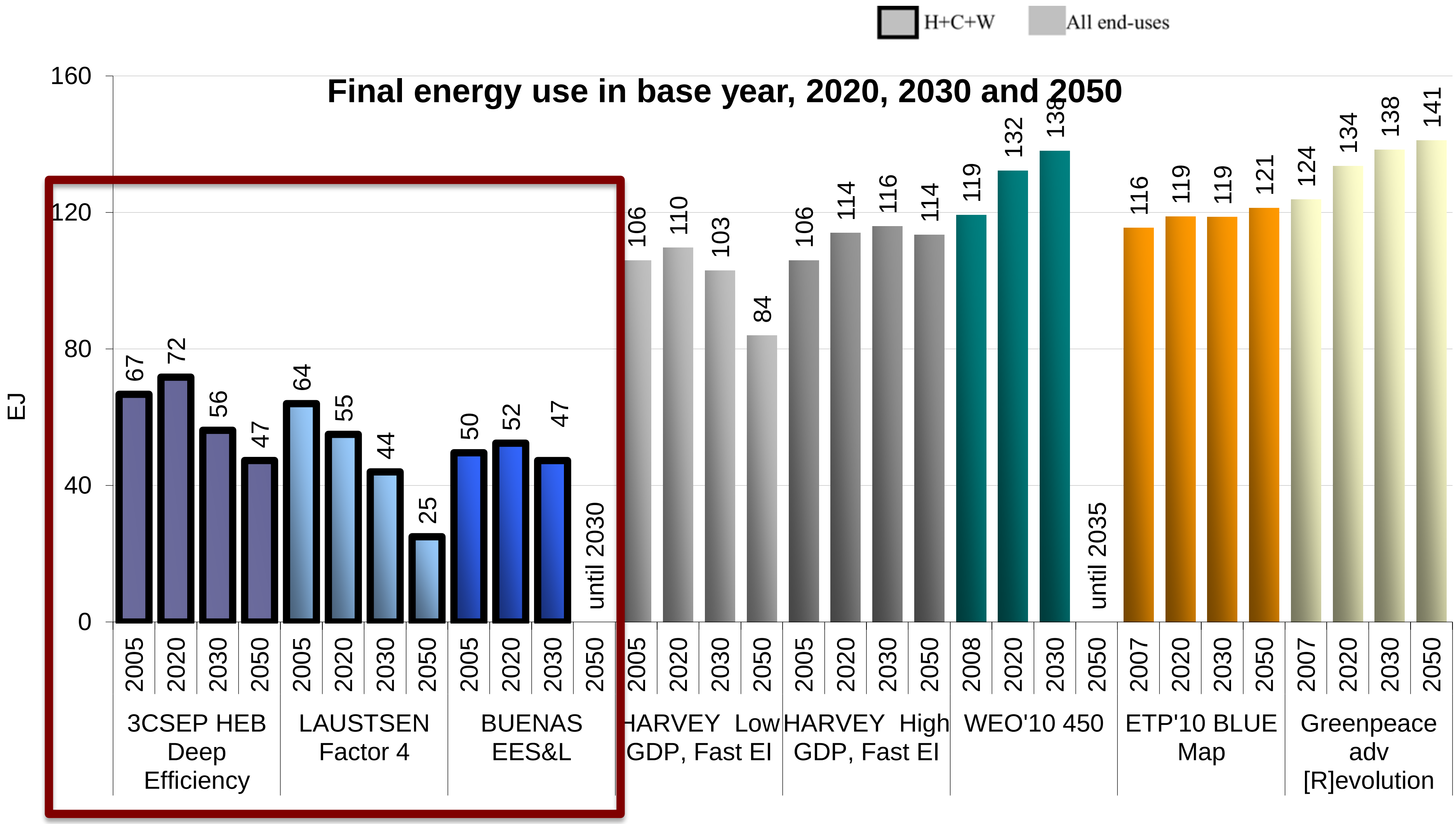
Final Energy for SH&C and floor area by building vintage. Deep Efficiency Scenario

China

India

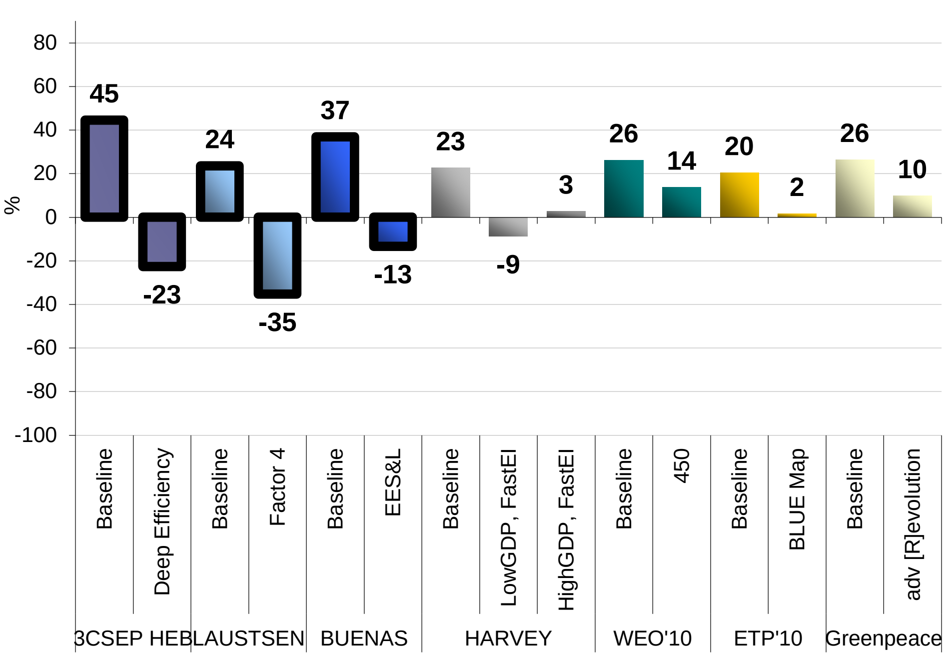


High potentials for SH&C energy use reduction

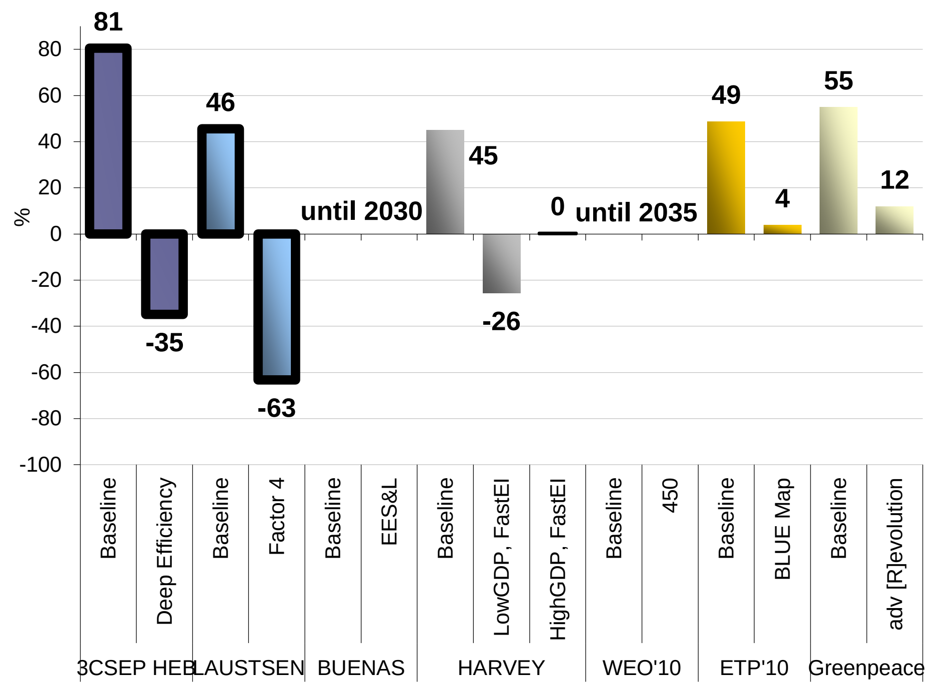


Longer periods offer higher savings

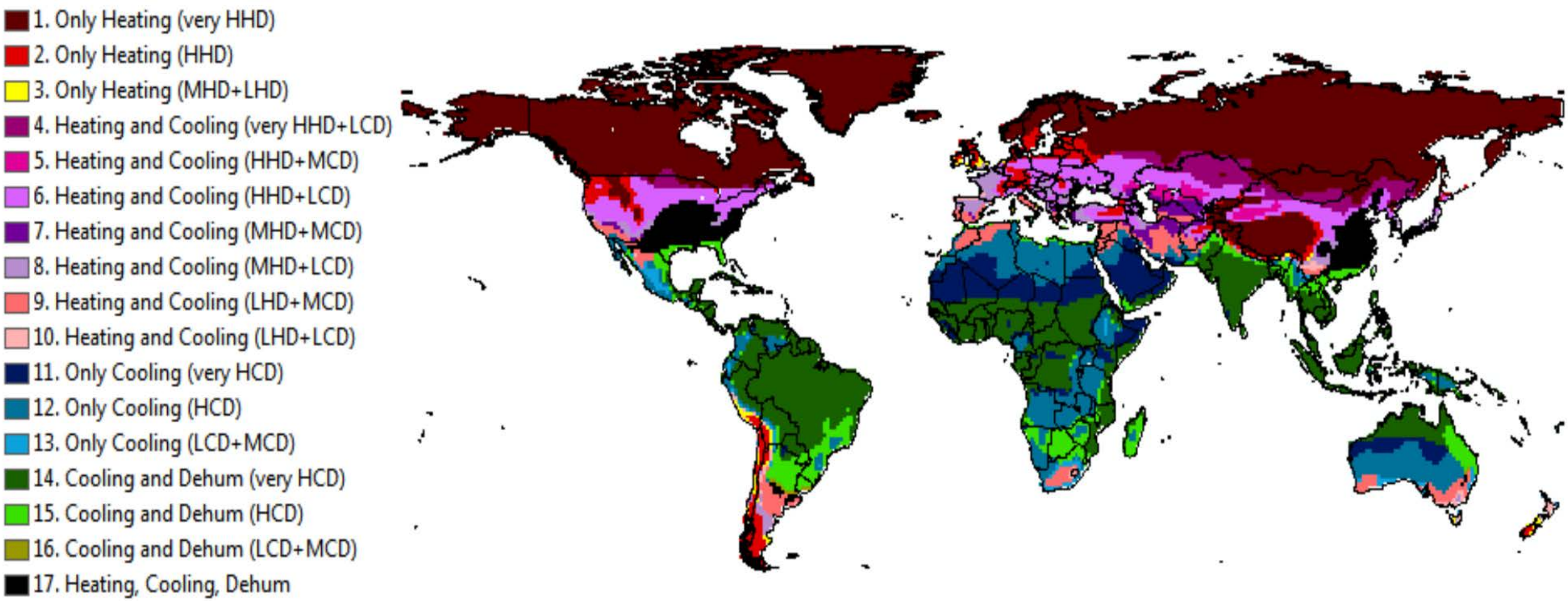
Final energy difference between year 2010 and 2030, %



Final energy difference between year 2010 and 2050, %



Climate Types



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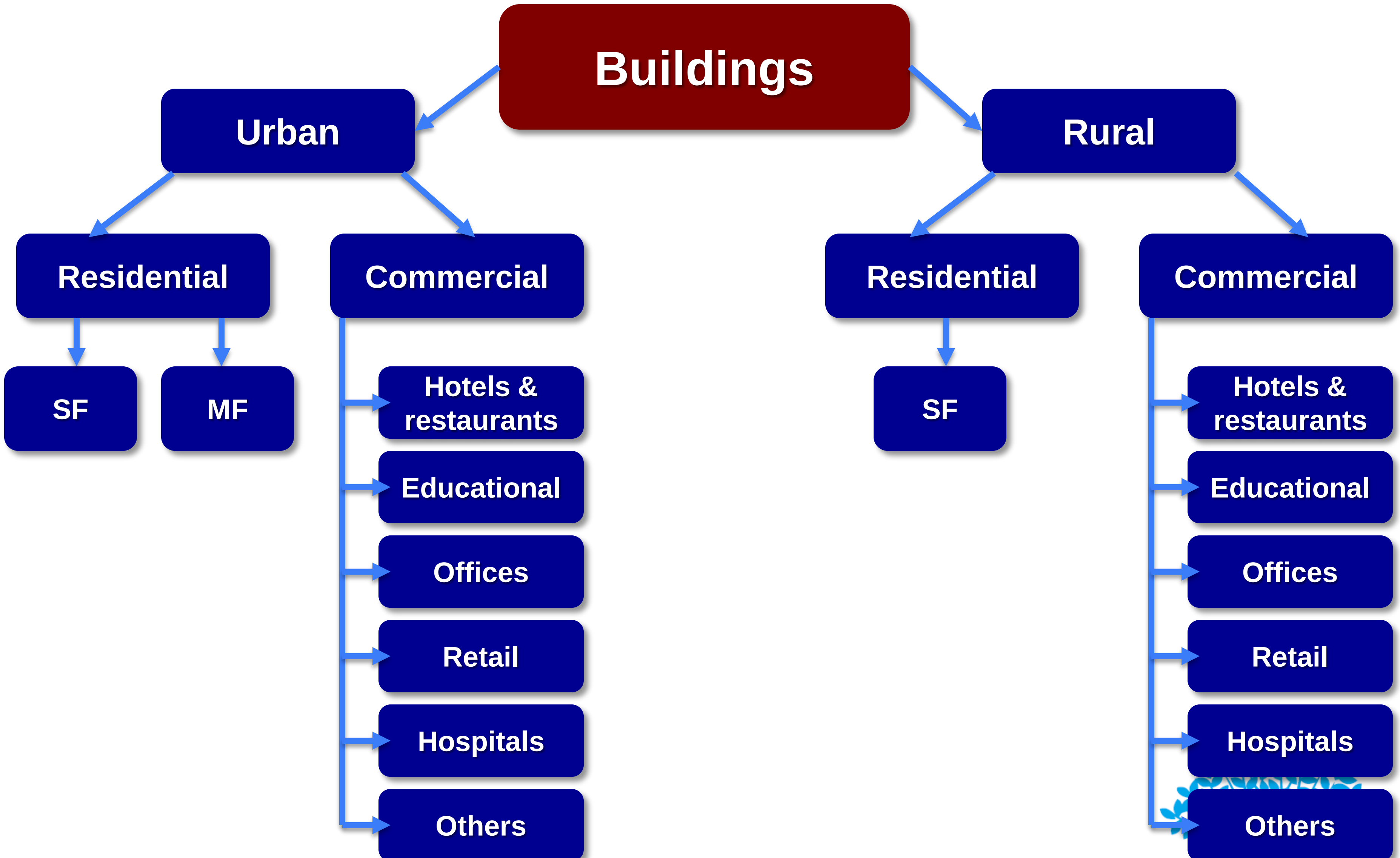
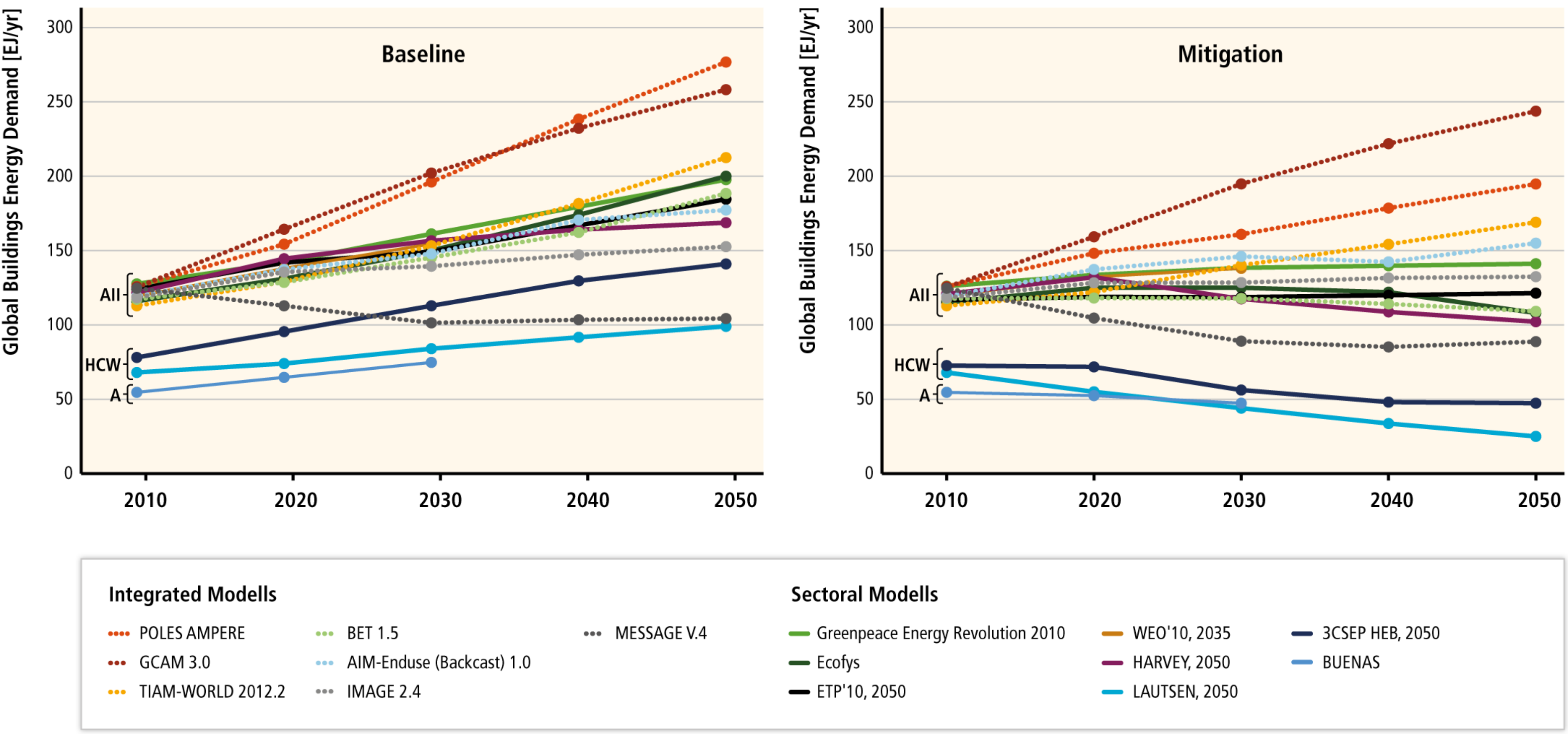
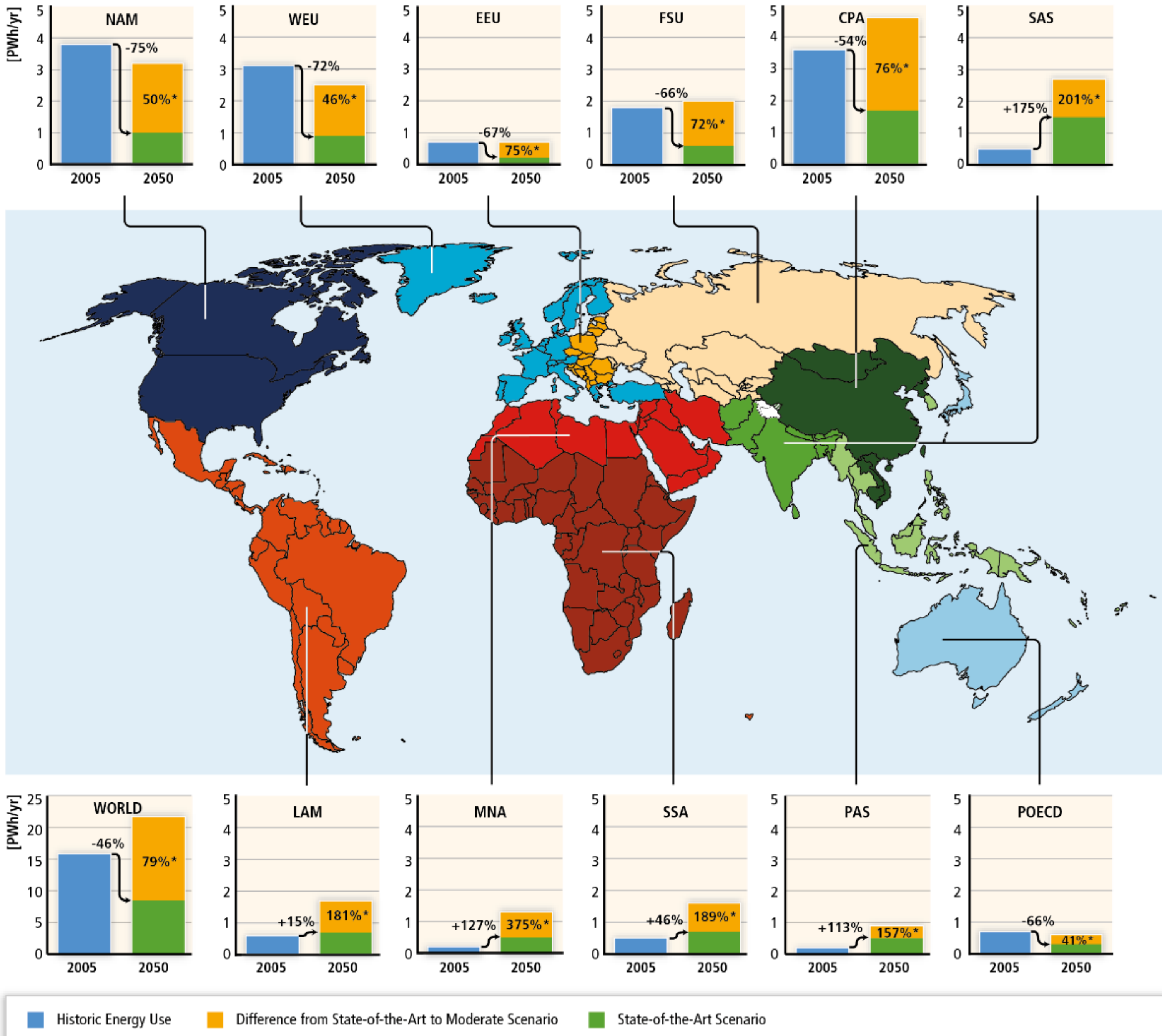
Key Assumptions on Building Types



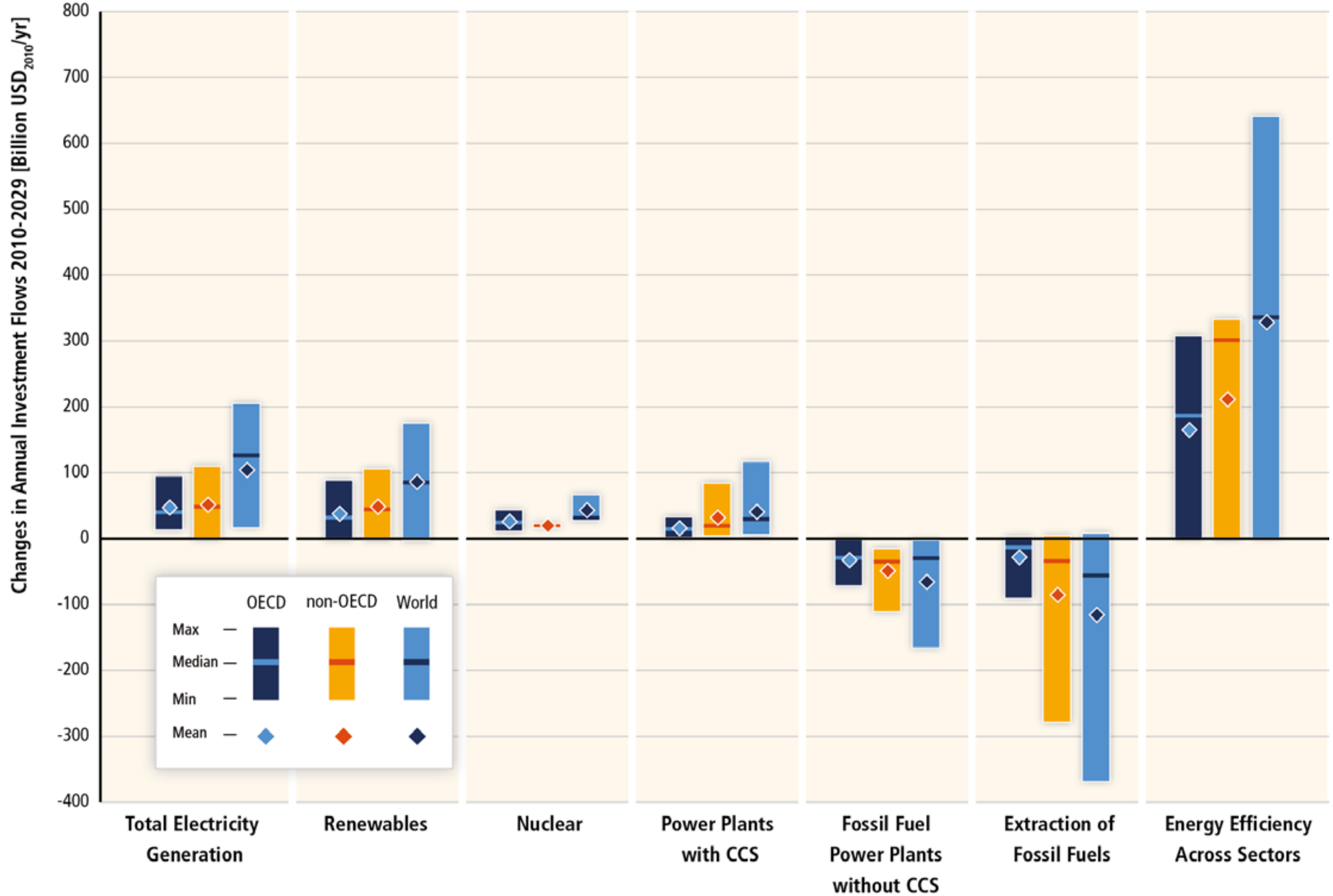

Baseline
Mitigation
Global Buildings Energy Demand [EJ/yr]
300
250
200
150
100
50
0
All
HCW
A
2010
2020
2030
2040
2050
Integrated Modells
POLES AMPERE
GCAM 3.0
TIAM-WORLD 2012.2
BET 1.5
AIM-Enduse (Backcast) 1.0
IMAGE 2.4
MESSAGE V.4
Sectoral Modells
Greenpeace Energy Revolution 2010
Ecofys
ETP'10, 2050
WEO'10, 2035
HARVEY, 2050
LAUTSEN, 2050
3CSEP HEB, 2050
BUENAS

3CSEP



*Lock-in Risk of Sub-Optimal Scenario Realative to Energy Use in 2005.

Substantial reductions in emissions would require large changes in investment patterns.



# of Studies:	4	4	5	4	4	5	4	4	5	4	4	5	4	4	5	4	4	5	3	3	4

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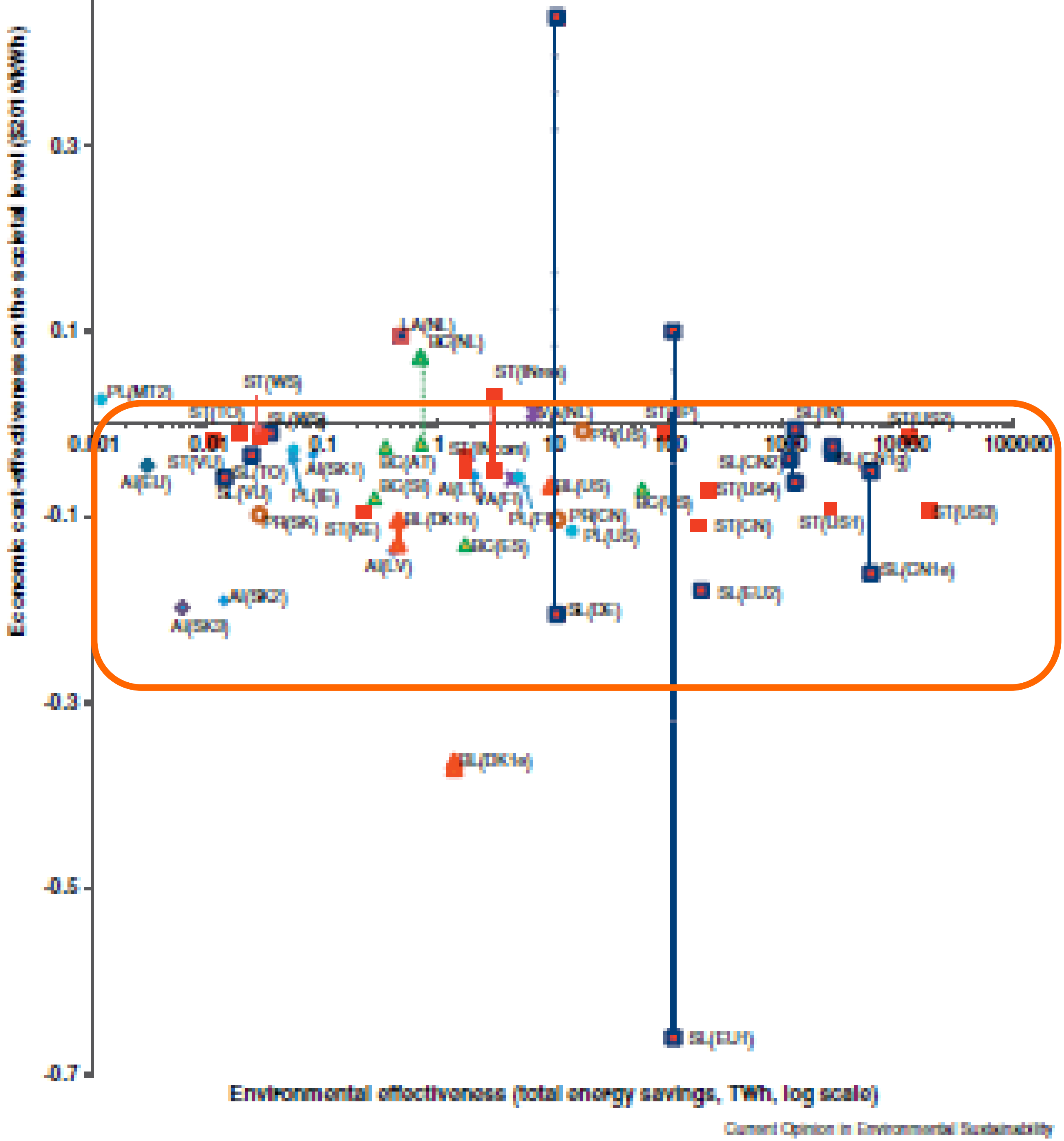
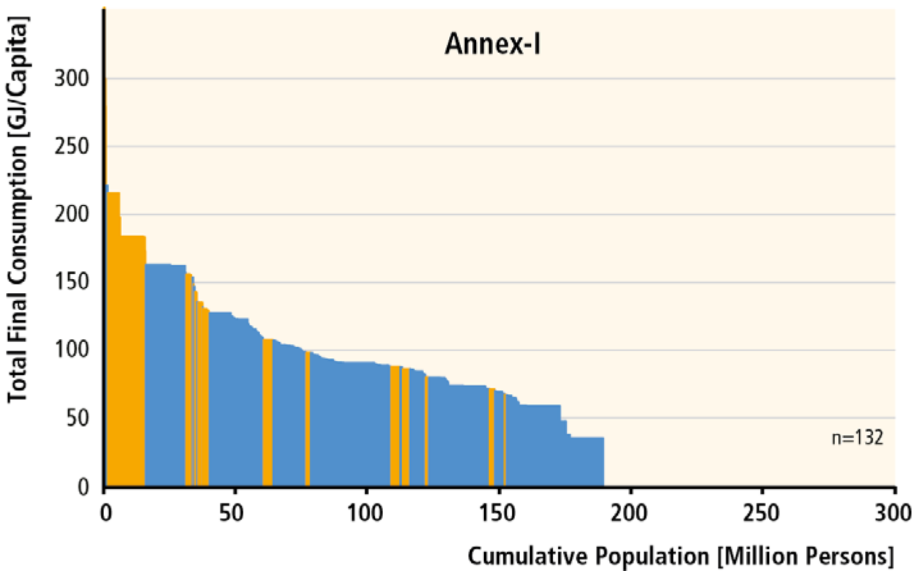
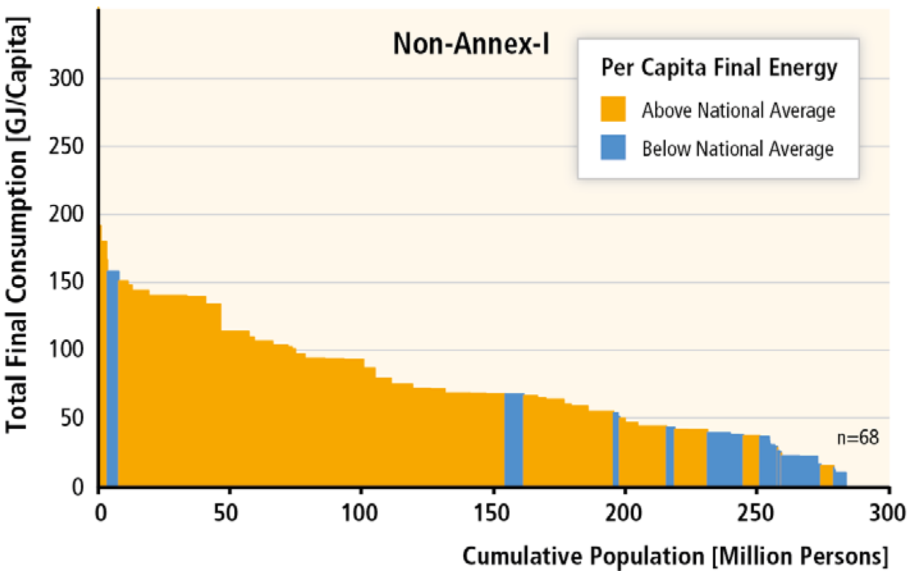
Cost of conserved carbon for implemented energy efficiency programs, post-ante evaluation results (based on data in Table 9.9 (boza-kiss et.al 2013 in COSUst)



Key Message 1: Urban areas are focal points of energy use and CO_2 emissions

Urban energy use: 67–76%
Urban CO_2 emissions: 71–76%
} of global total





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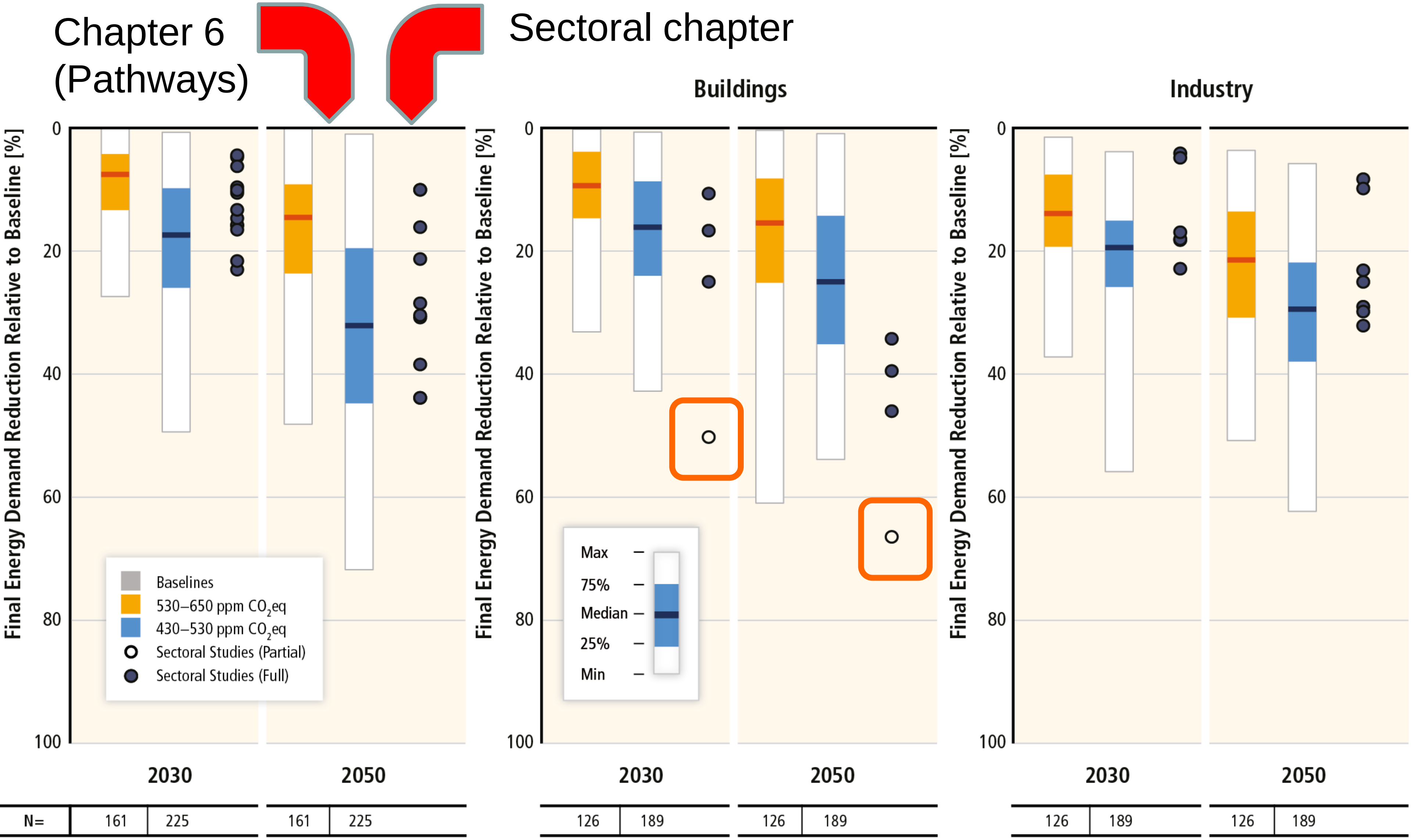
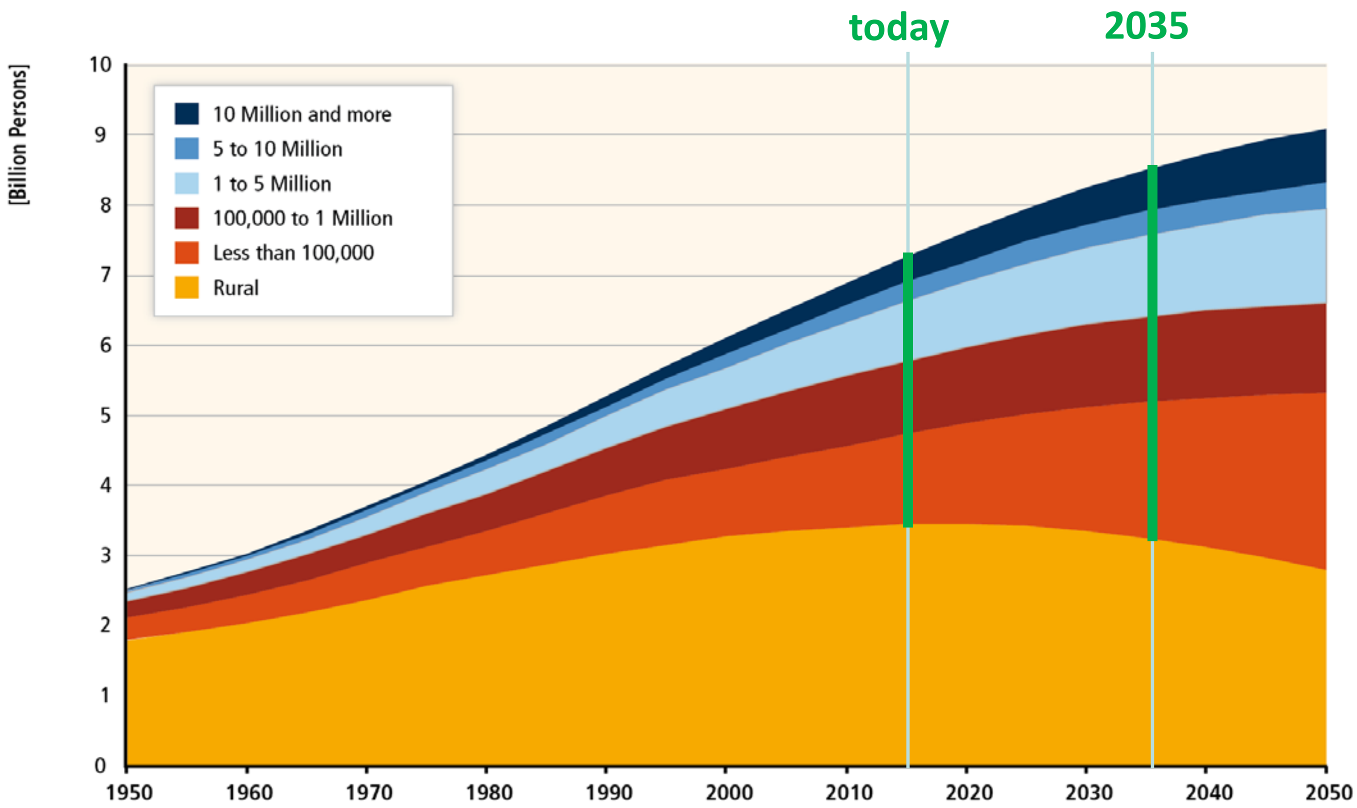
Energy Demand Reduction Potential



Source: Figure SPM.11

Window of opportunity in next two decades as large portions of global urban areas have yet to be built



Need to avoid emissions lock-in from ***constructing*** *and* ***operating*** *the built environment*

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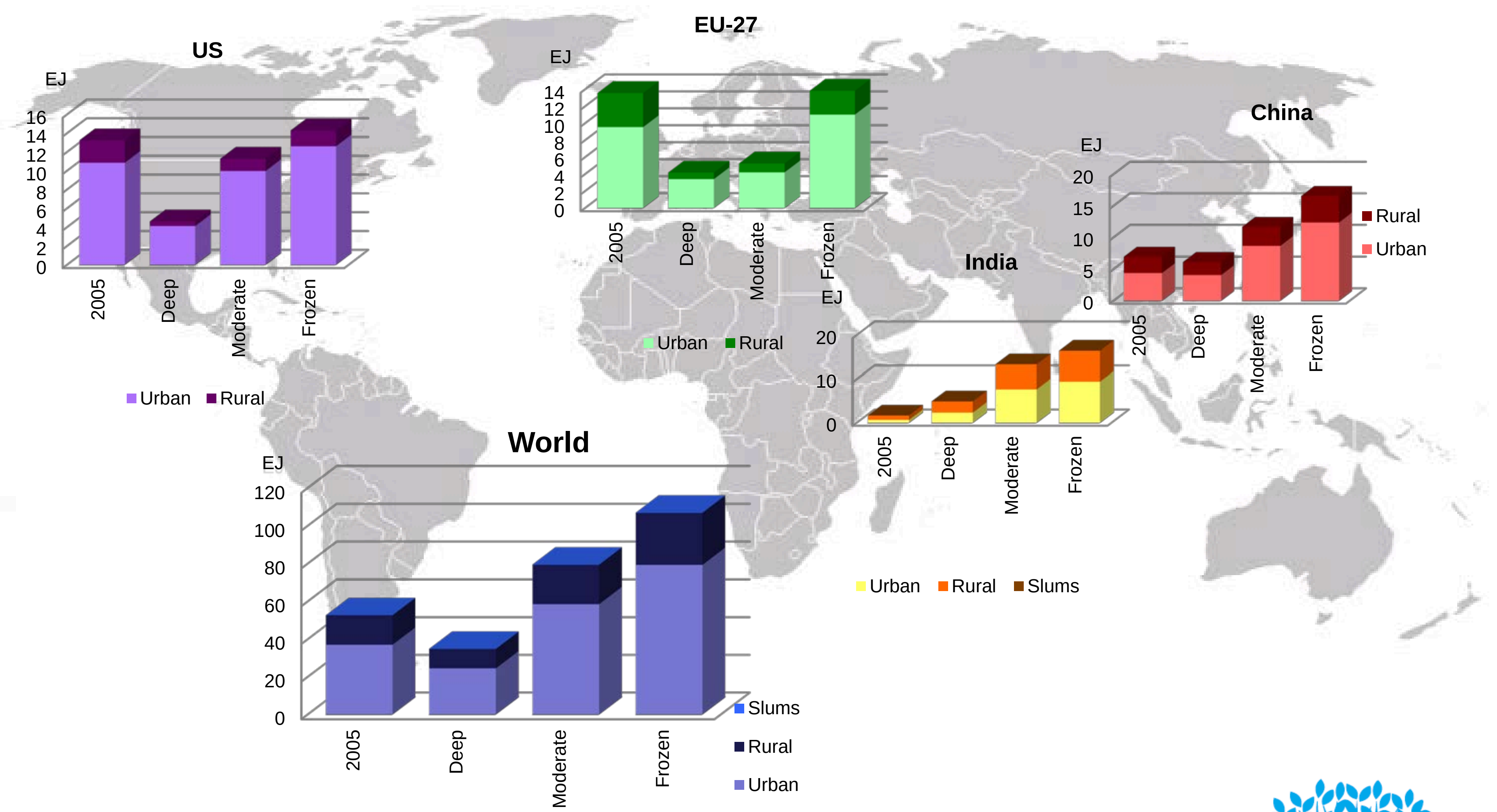
Urban vs. Rural Energy Use



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