Mitigation of Climate Change

CENTER FOR CLIMATE CHANGE
AND SUSTAINABLE ENERGY POLICY

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Paris

December 7, 2015

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INTERGOVERNMENTAL PANEL ON climate change

CLIMATE CHANGE 2014

Mitigation of Climate Change

Co-Chairs during AR5:
Ottmar Edenhofer
Youba Sokona
Ramon Pichs Madruga

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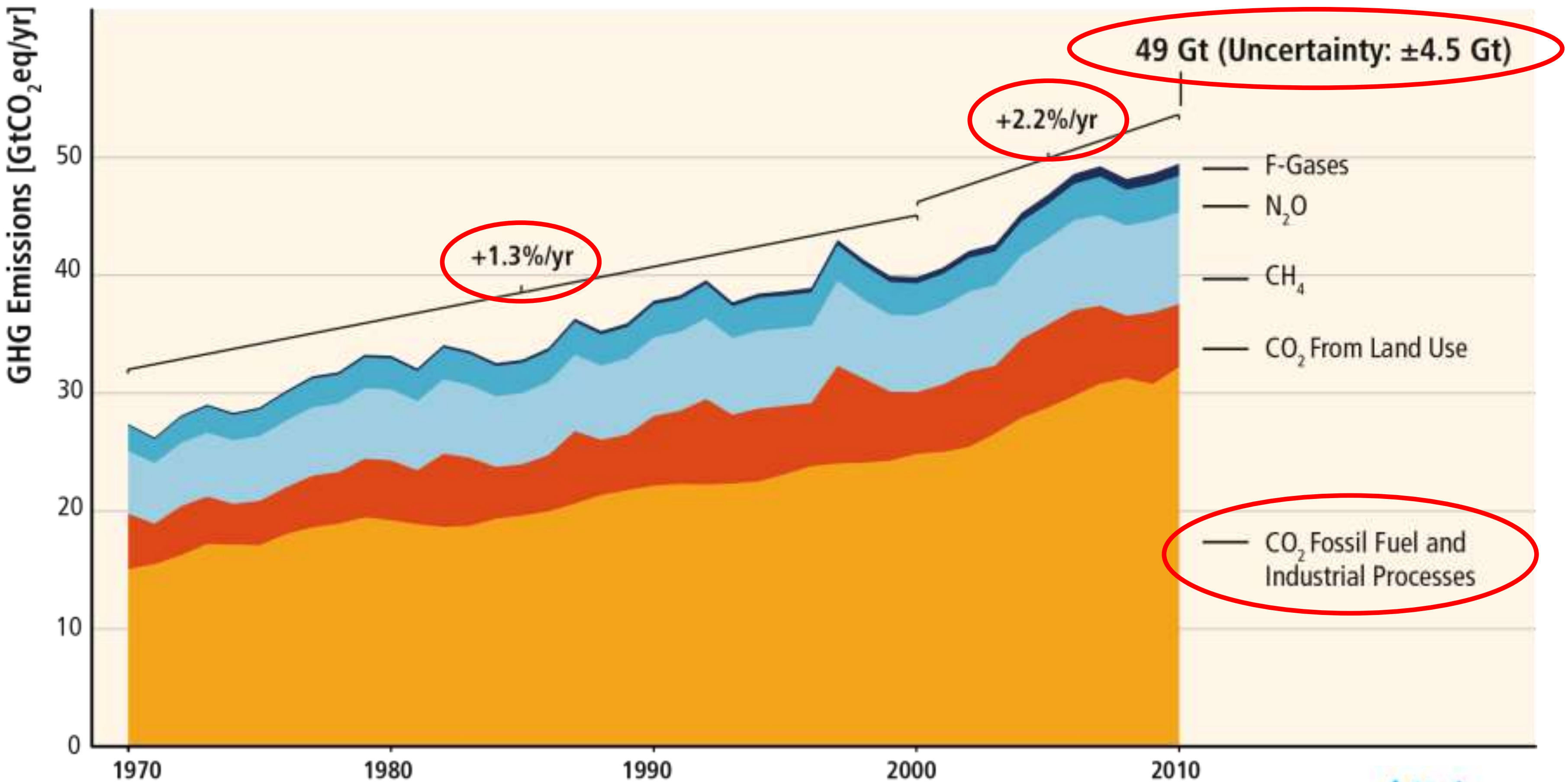
GHG emissions growth has accelerated despite reduction efforts.

GHG emissions growth between 2000 and 2010 has been larger than in the previous three decades.



Based on Figure 1.3

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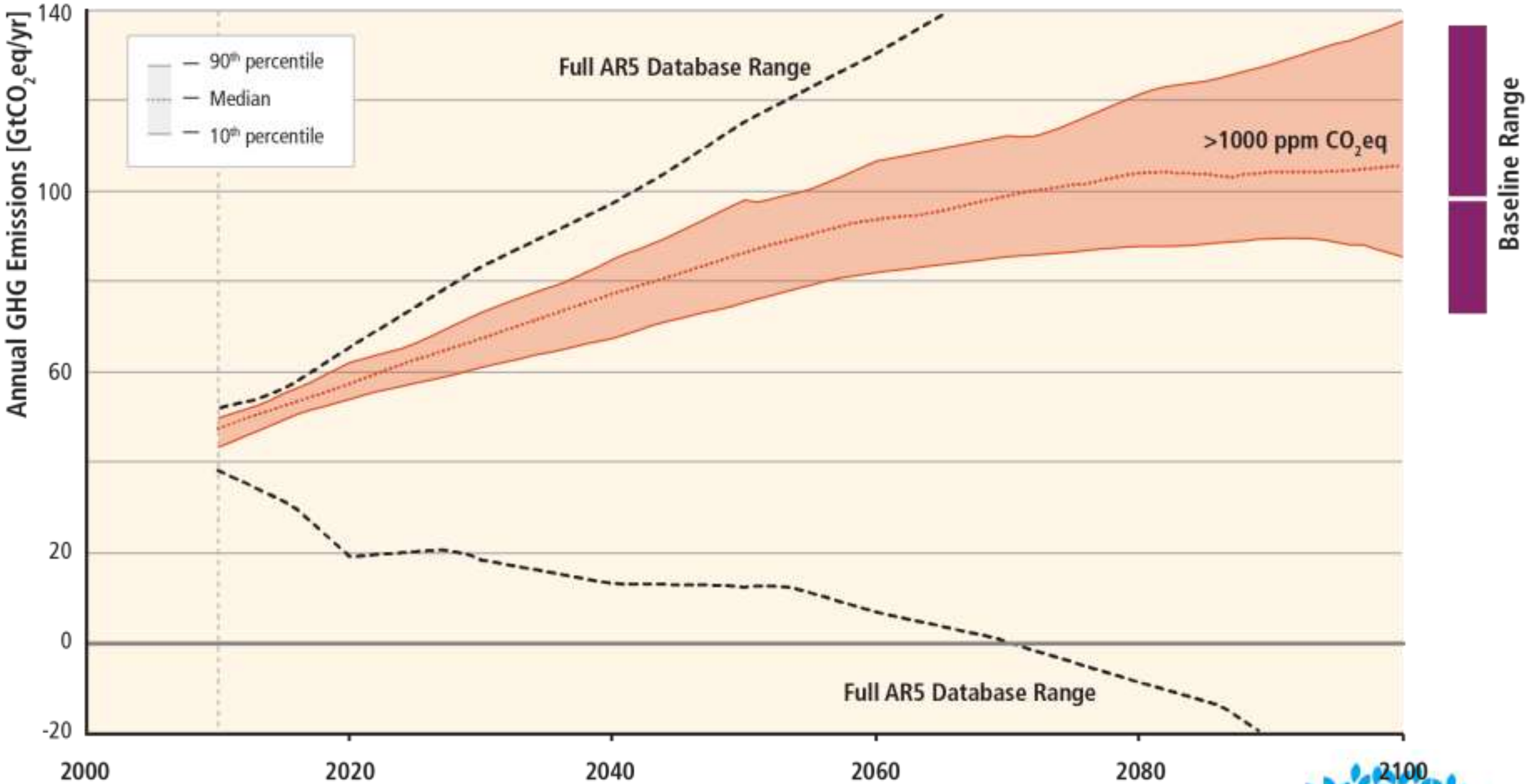
Limiting warming to 2°C is still possible

However

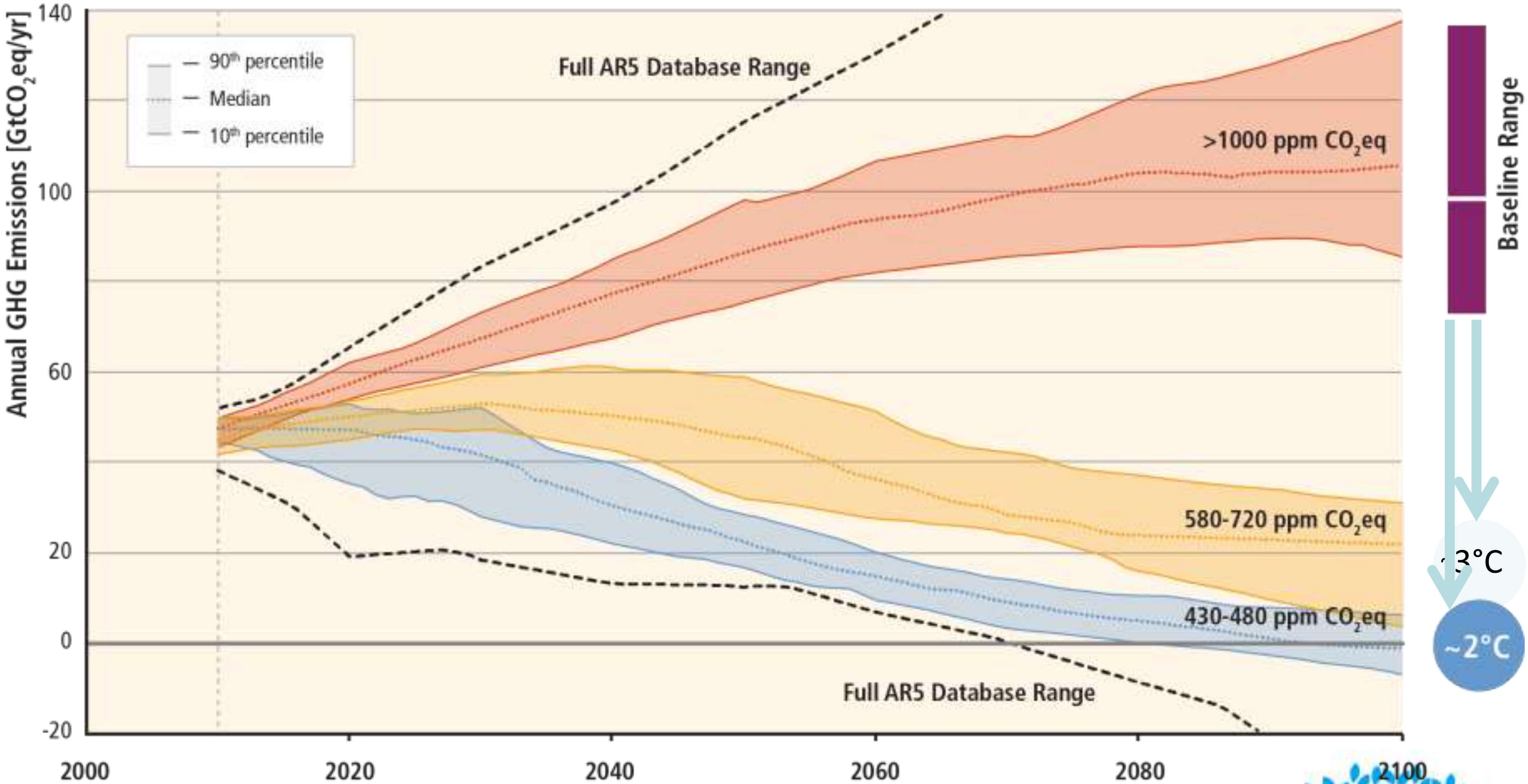
it involves substantial technological, economic and institutional challenges.

Stabilization of atmospheric GHG concentrations requires moving away from business as usual.



Based on Figure 6.7

Lower ambition mitigation goals require similar reductions of GHG emissions.



Based on Figure 6.7

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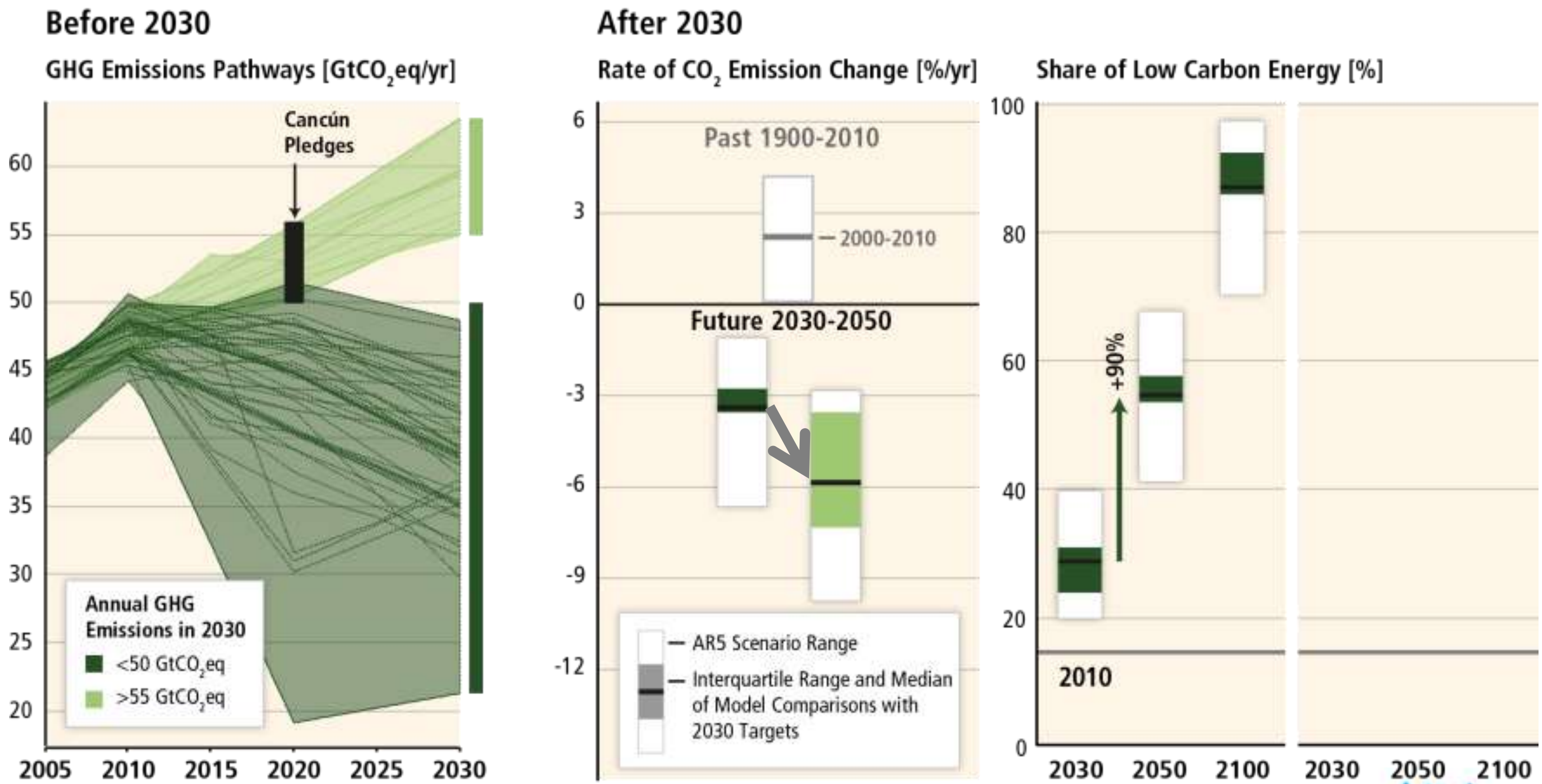
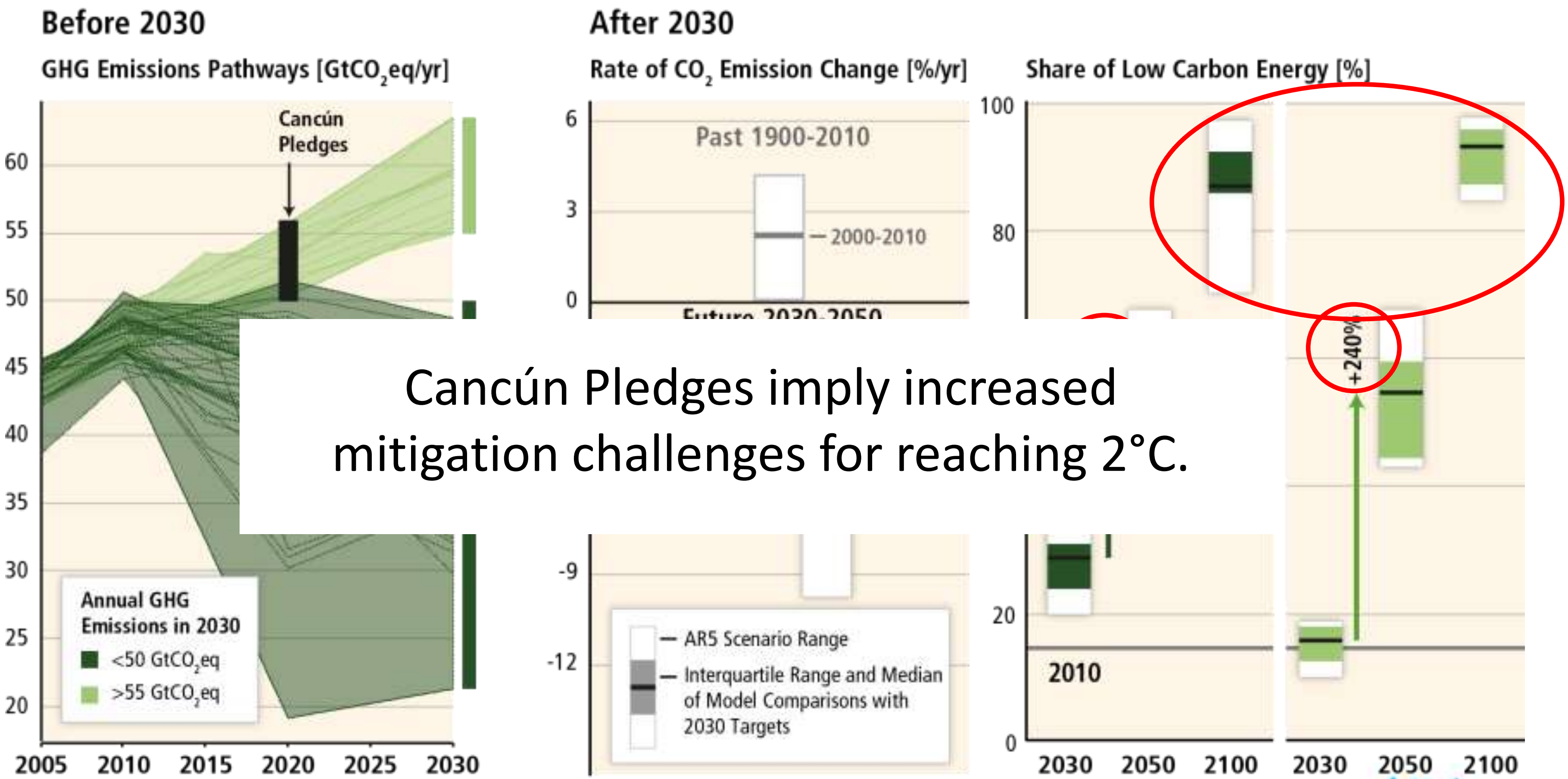
Delaying mitigation is estimated to increase the difficulty and narrow the options for limiting warming to 2°C.



Based on Figures 6.32 and 7.16

Delaying mitigation is estimated to increase the difficulty and narrow the options for limiting warming to 2°C.



Cancún Pledges imply increased mitigation challenges for reaching 2°C.

Based on Figures 6.32 and 7.16

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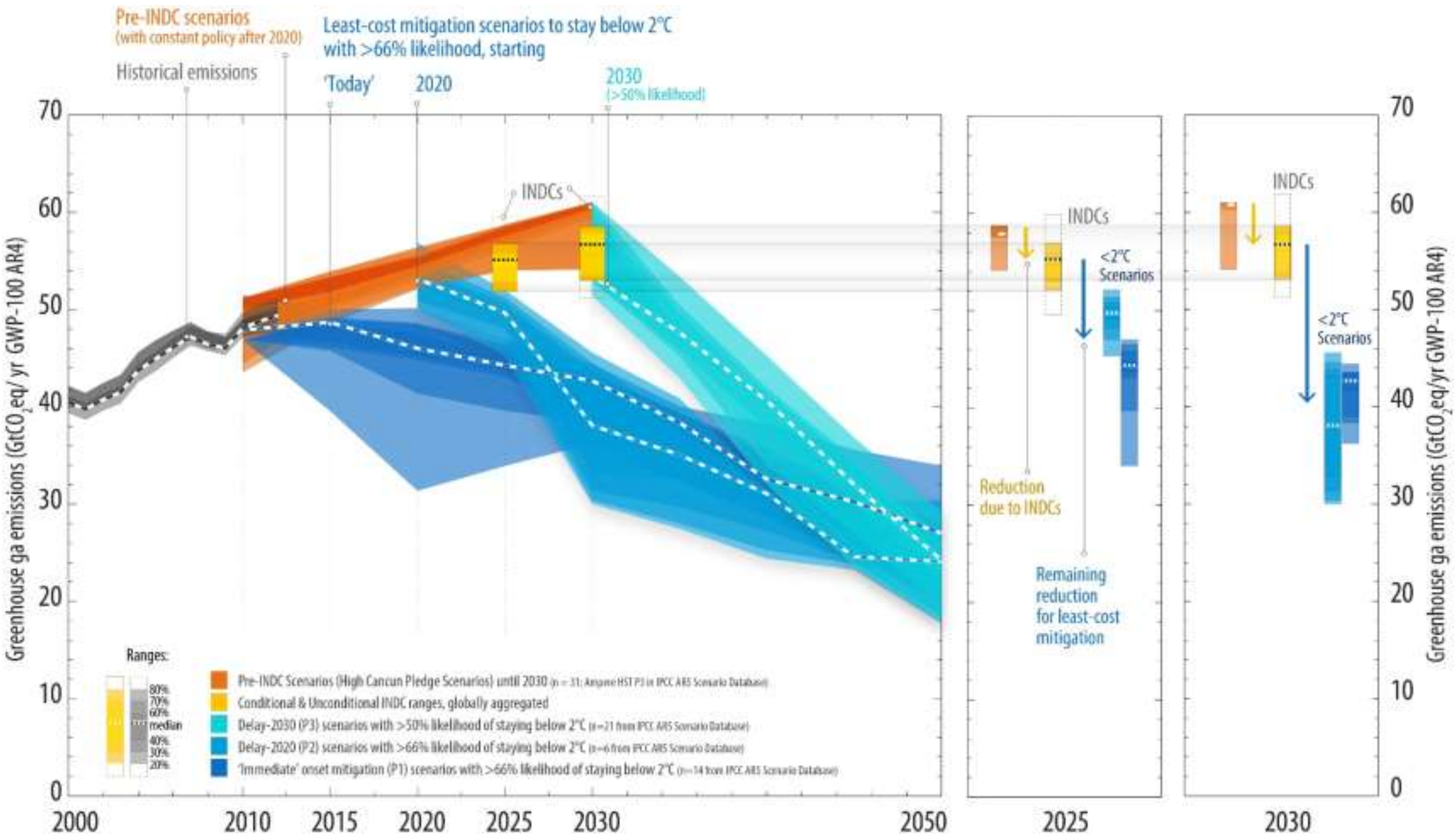
INDCs may cap 21st century warming at 2.7C

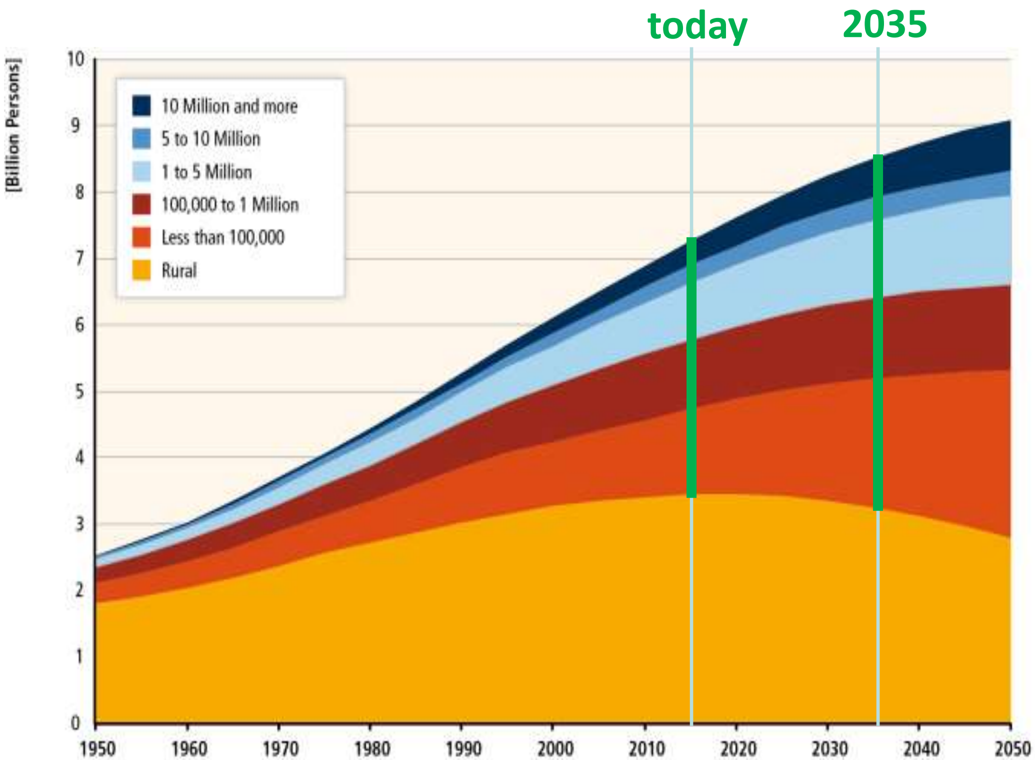


UNFCCC: SYNTHESIS REPORT ON THE AGGREGATE
EFFECT OF INTENDED NATIONALLY DETERMINED CONTRIBUTIONS (INDCs), November 2015

Mitigation cost estimates vary, but do not strongly affect global GDP growth.

- Reaching mitigation goals does not have to compromise development :
  - a 0.04-0.14% loss in annual GDP growth (business-as-usual baseline: 1.6-3.0% GDP growth).

Mitigation opportunities in cities and buildings



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

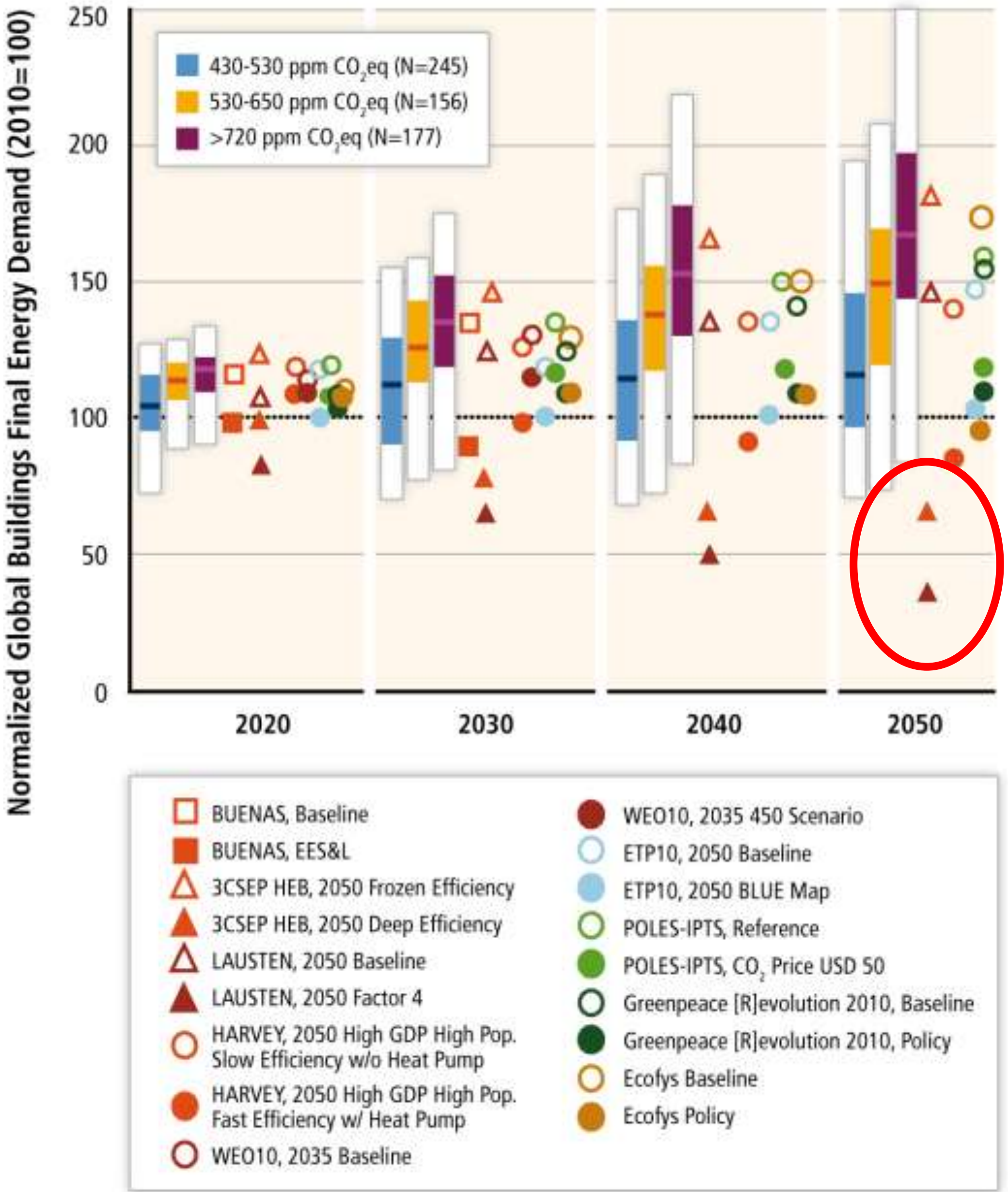
- **Urban areas generate 80% of GDP and 71% - 76% of CO2 emissions from global energy use**
- **Each week the urban population increases by 1.3 million**
- **Over 70% of global building energy use growth until 2050 will take place in developing country cities**
- **This enormous expected increase poses both an opportunity and responsibility**

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

- Urban design and form
- Energy efficient buildings
  - low-energy architecture
    - avoiding mechanical 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
- Lowering embodied energy in the built infrastructure –
  - affordable low-carbon, durable construction materials

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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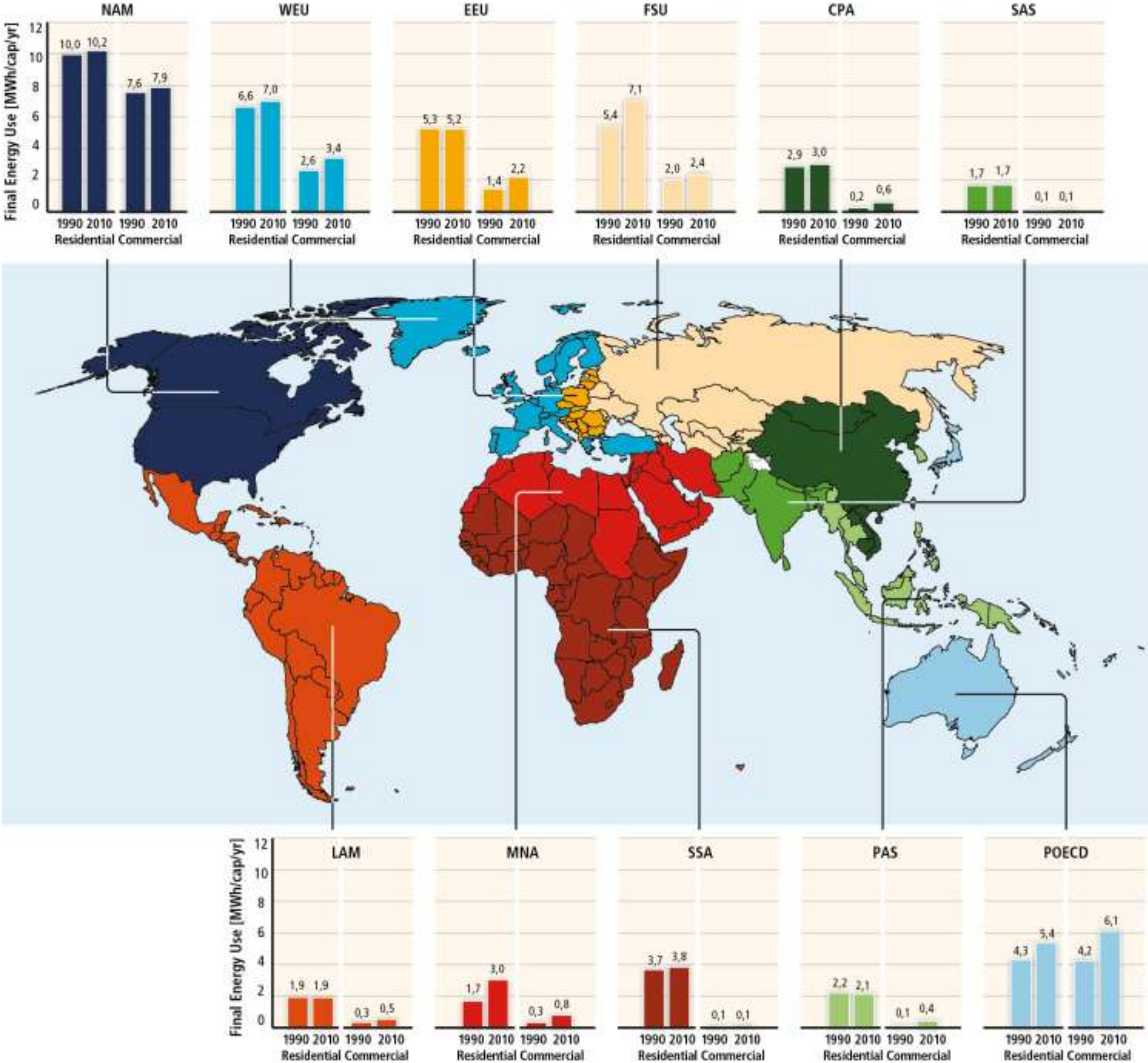
55.000 Passive Houses exist in 28 European member countries

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



Thank you for your attention

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Supplementary slides

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

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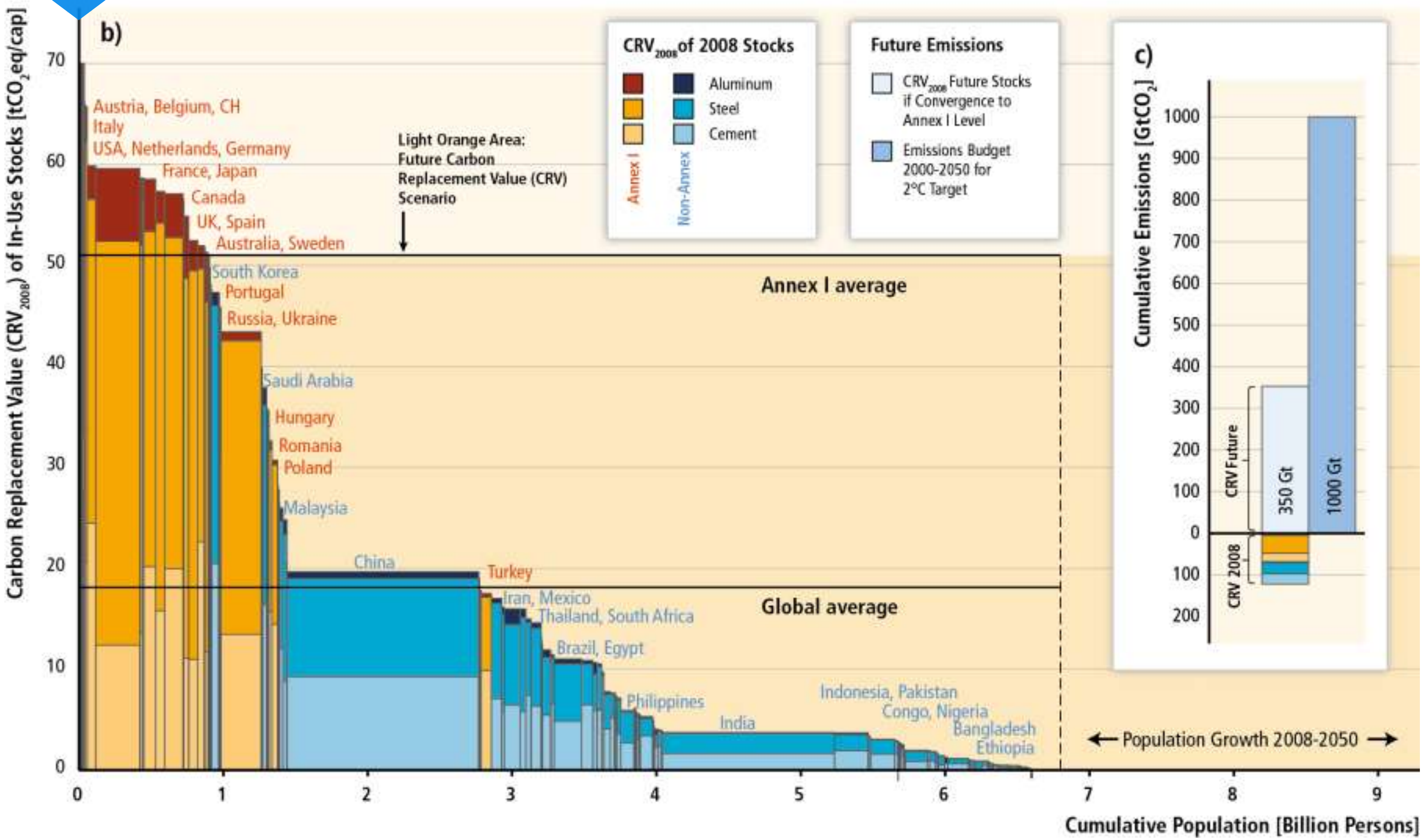
“Overall, the potential for co-benefits for energy end-use measures outweigh the potential for adverse side-effects, whereas the evidence suggests this may not be the case for all energy supply and AFOLU measures.” (SPM 4.1)

How mitigation options can go hand-in-hand with development goals
(selected co-benefits, focus on developing countries)

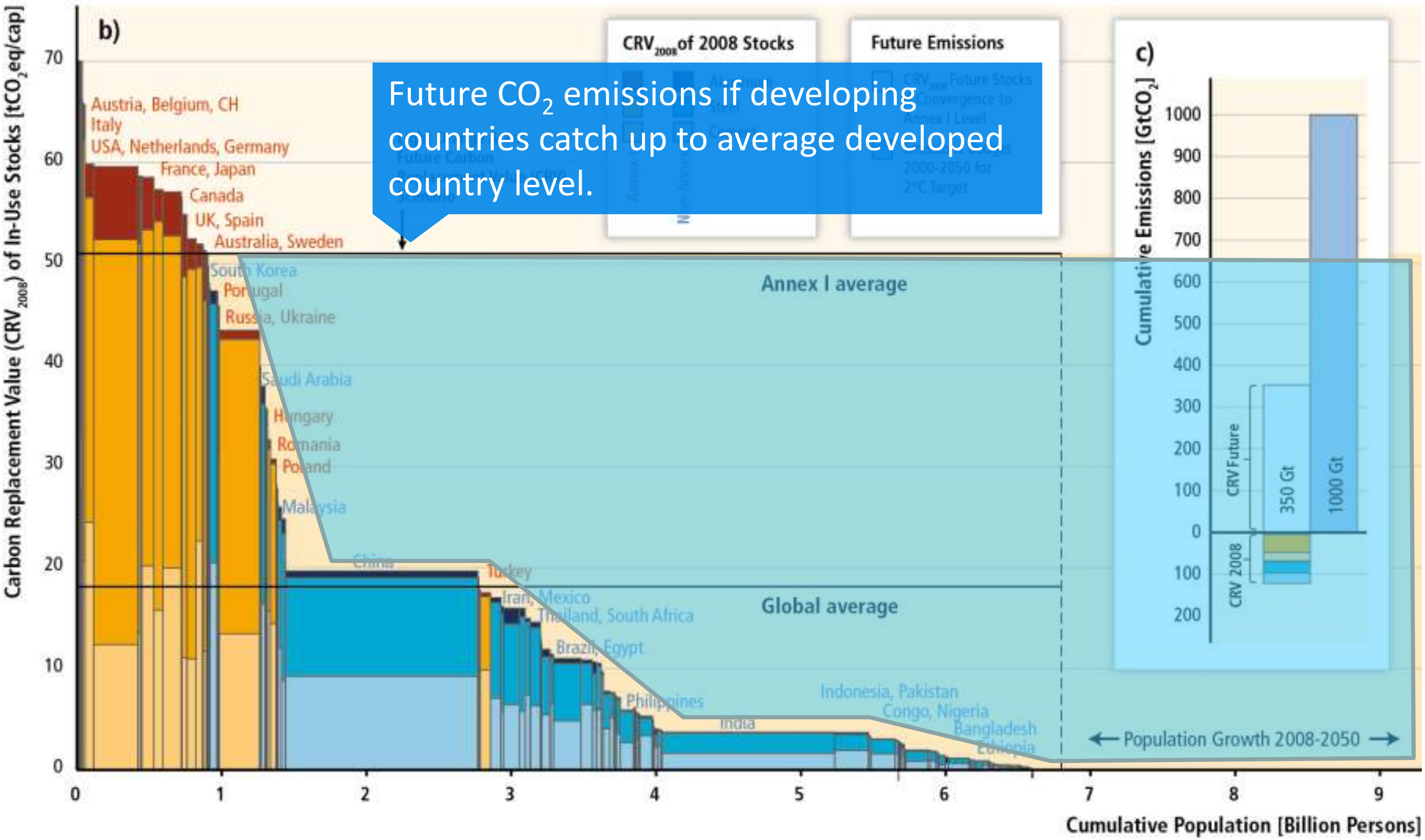
- Health – 2 m annually die from indoor air pollution from cooking, many women and children
- Increased productive time for women and children
- Air quality improvement – indoor and outdoor
- decreasing the burden of energy generation capacity development needs
- Efficiency increases access to energy 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

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

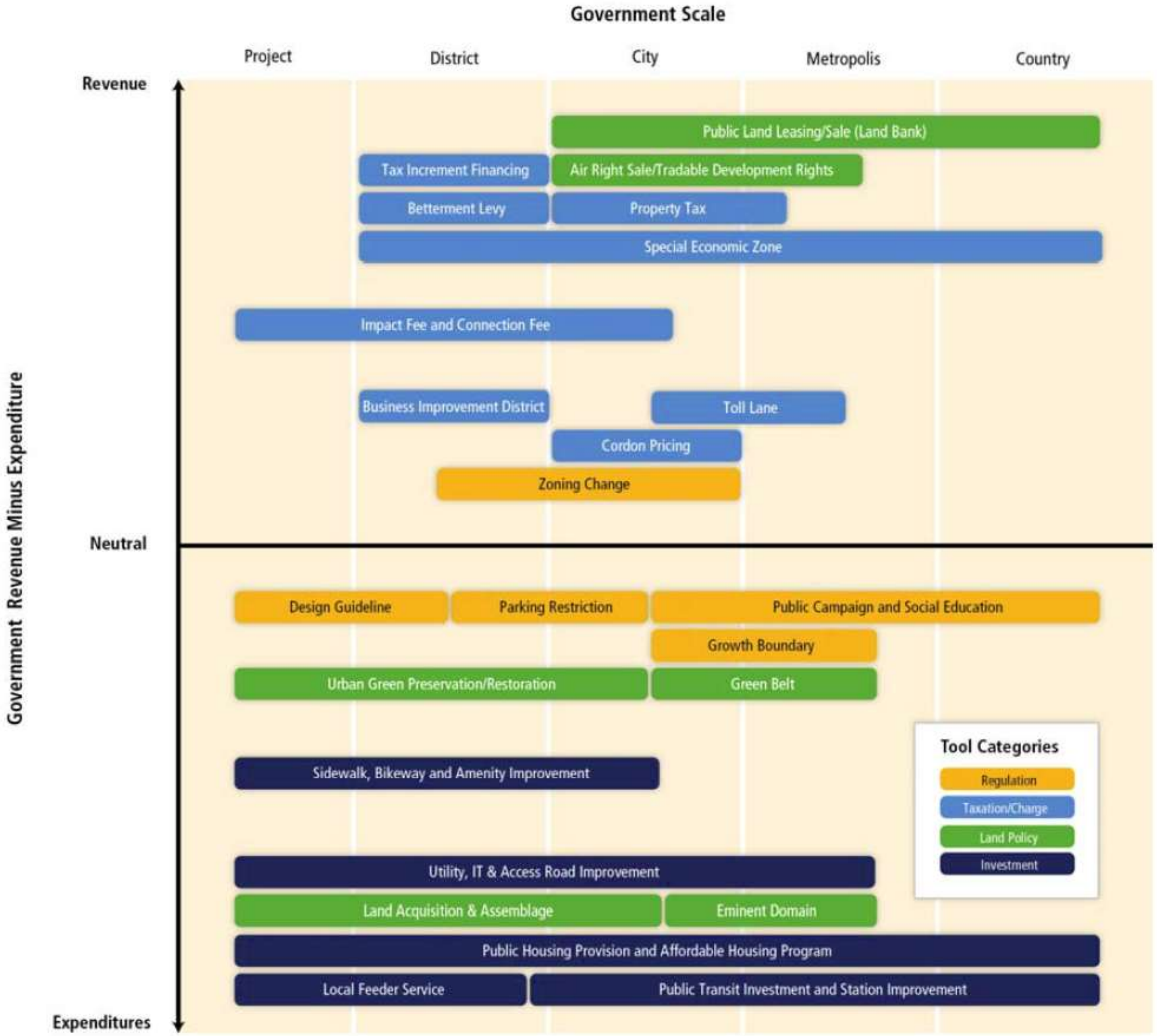
Total CO_2 emissions (per capita) needed to build up today's infrastructure



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



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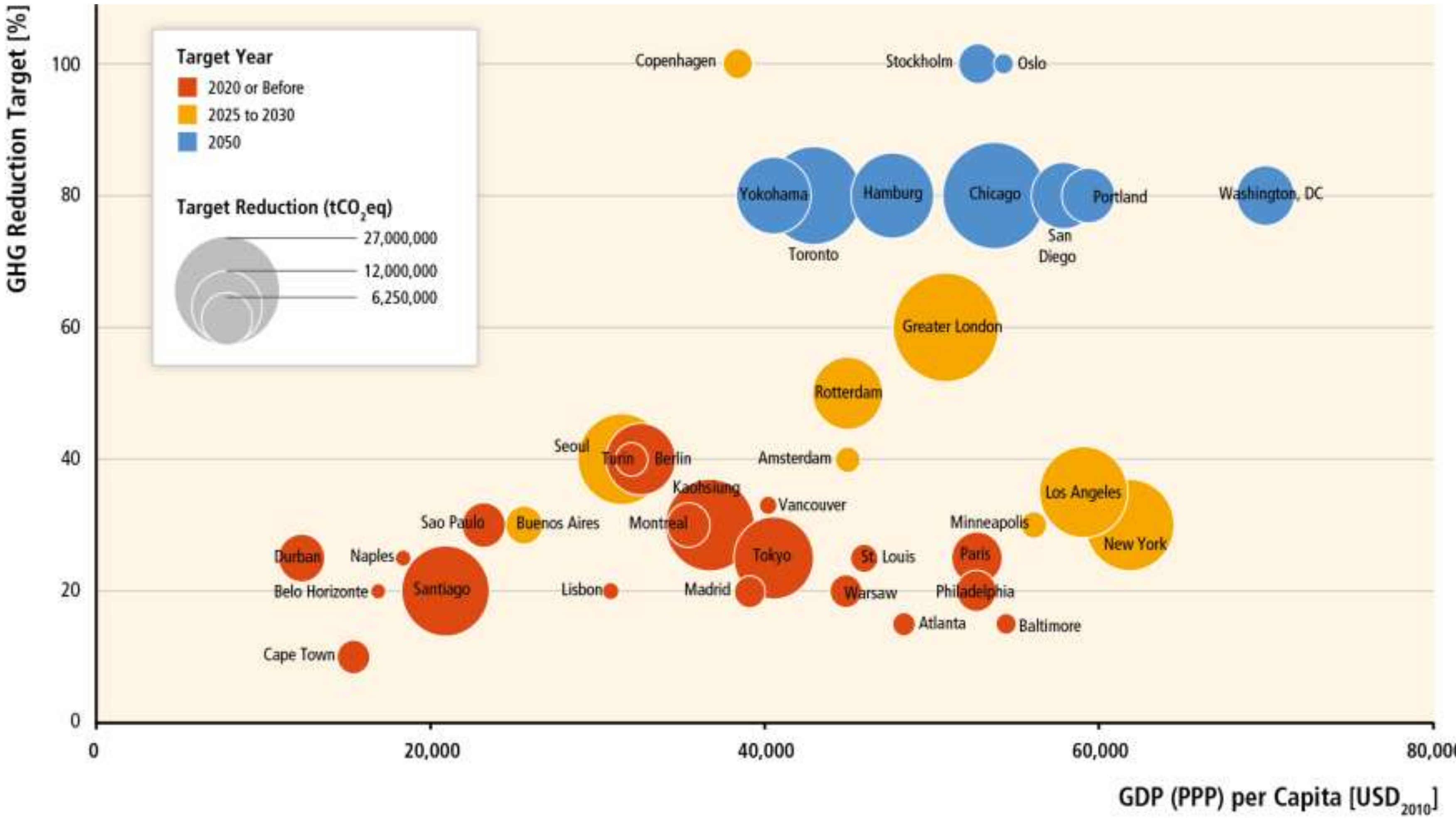
Key Message 6: Thousands of cities are undertaking climate action plans, but their impact on urban emissions is uncertain



Summary

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

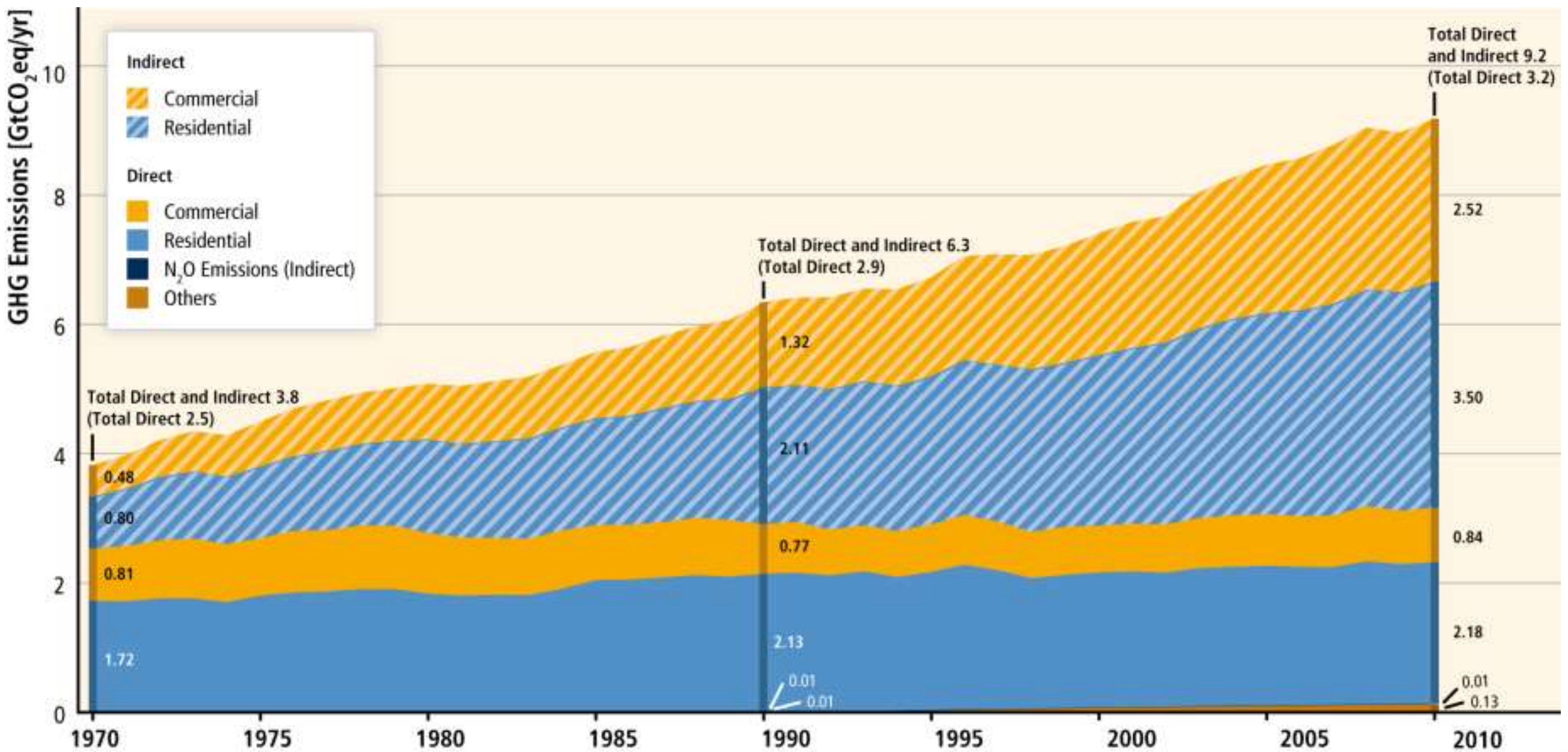
2. The feasibility of spatial planning instruments for climate change mitigation depends highly upon each city's financial and governance capability.

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

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

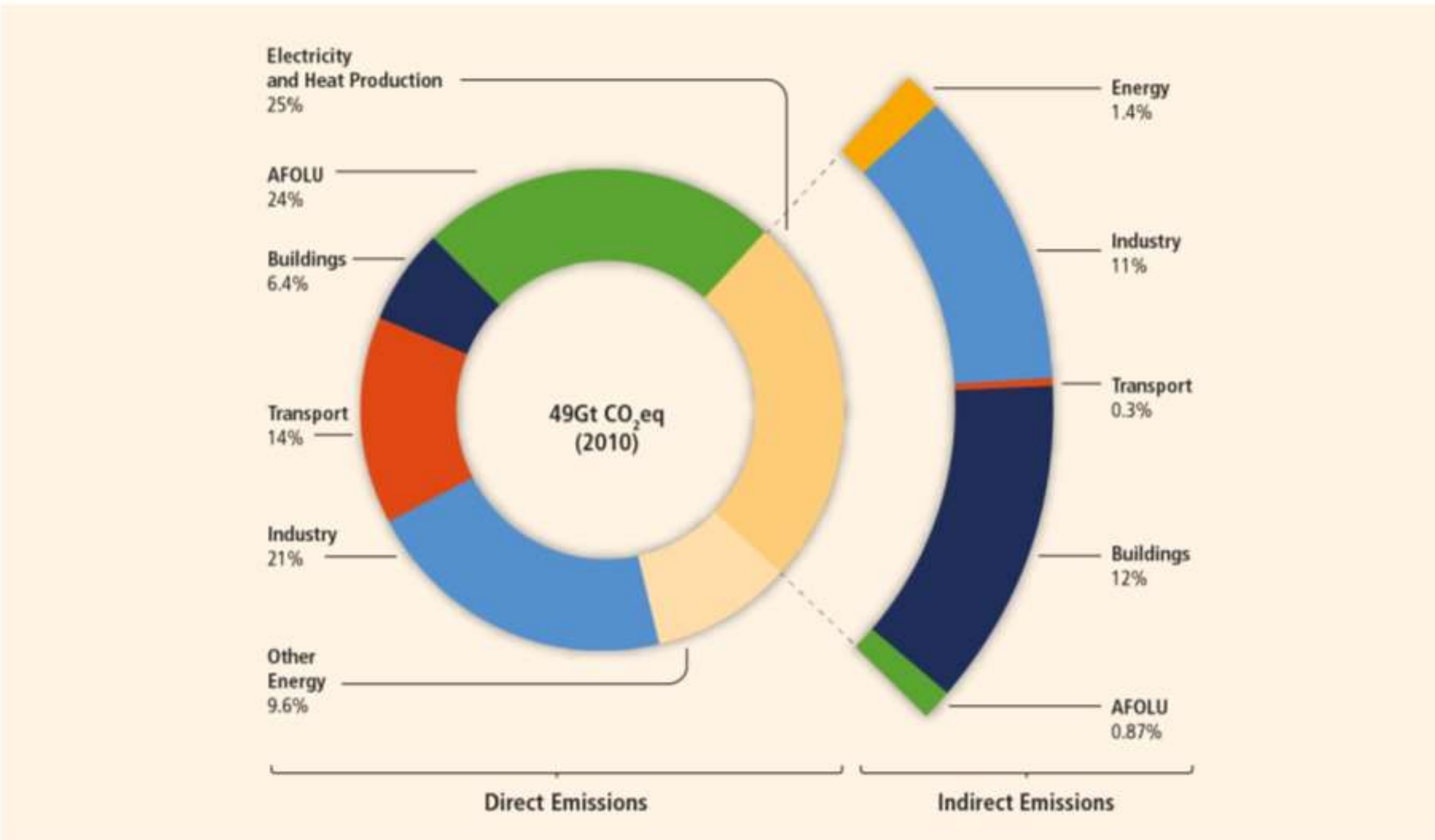
In 2010, the building sector accounted for

- 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

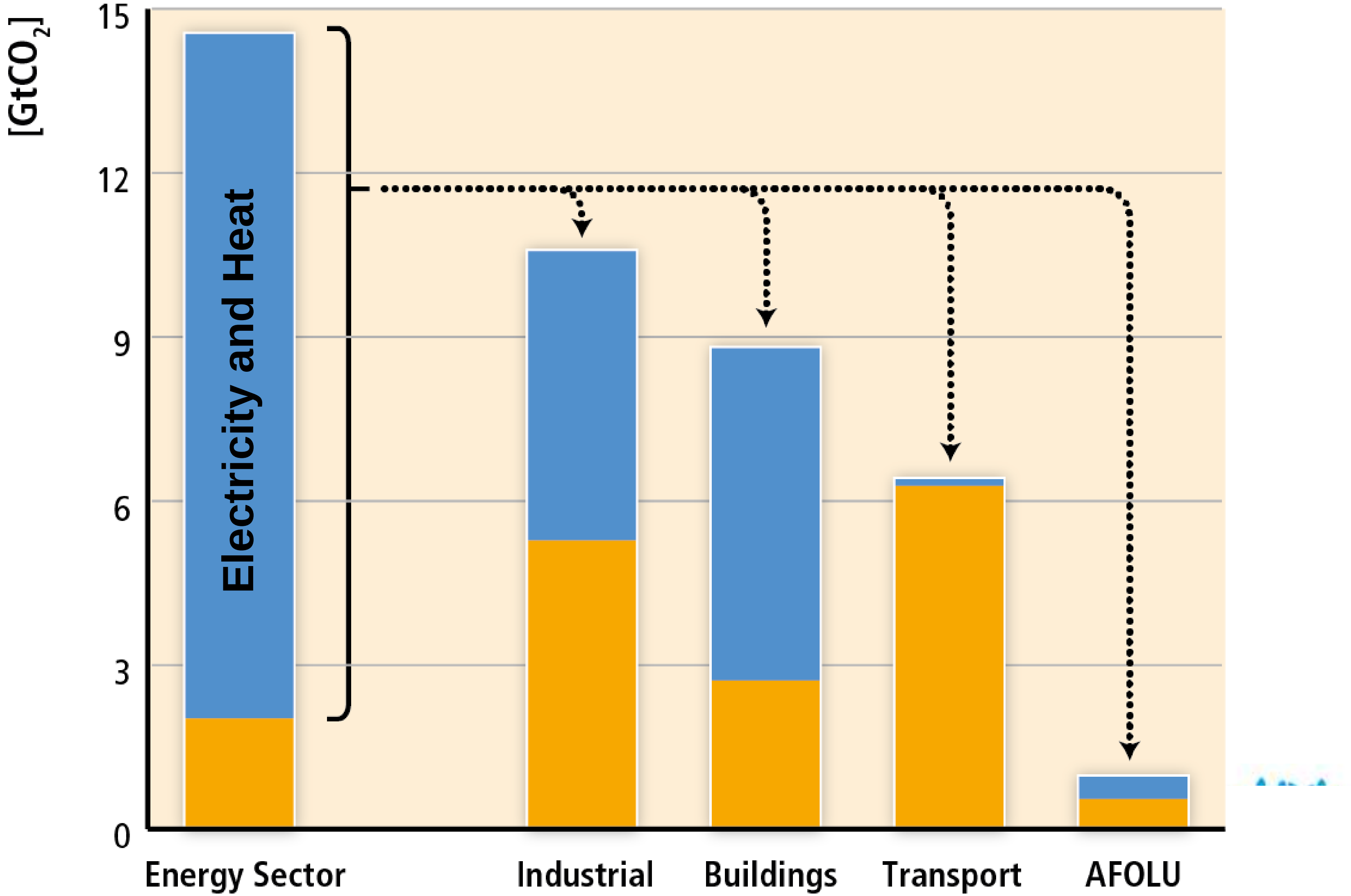


GHG Emissions [GtCO2eq/yr]
Indirect
Commercial
Residential
Direct
Commercial
Residential
N2O Emissions (Indirect)
Others
Total Direct and Indirect 3.8
(Total Direct 2.5)
0.48
0.80
0.81
1.72
Total Direct and Indirect 6.3
(Total Direct 2.9)
1.32
2.11
0.77
2.13
0.01
0.01
Total Direct
and Indirect 9.2
(Total 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

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



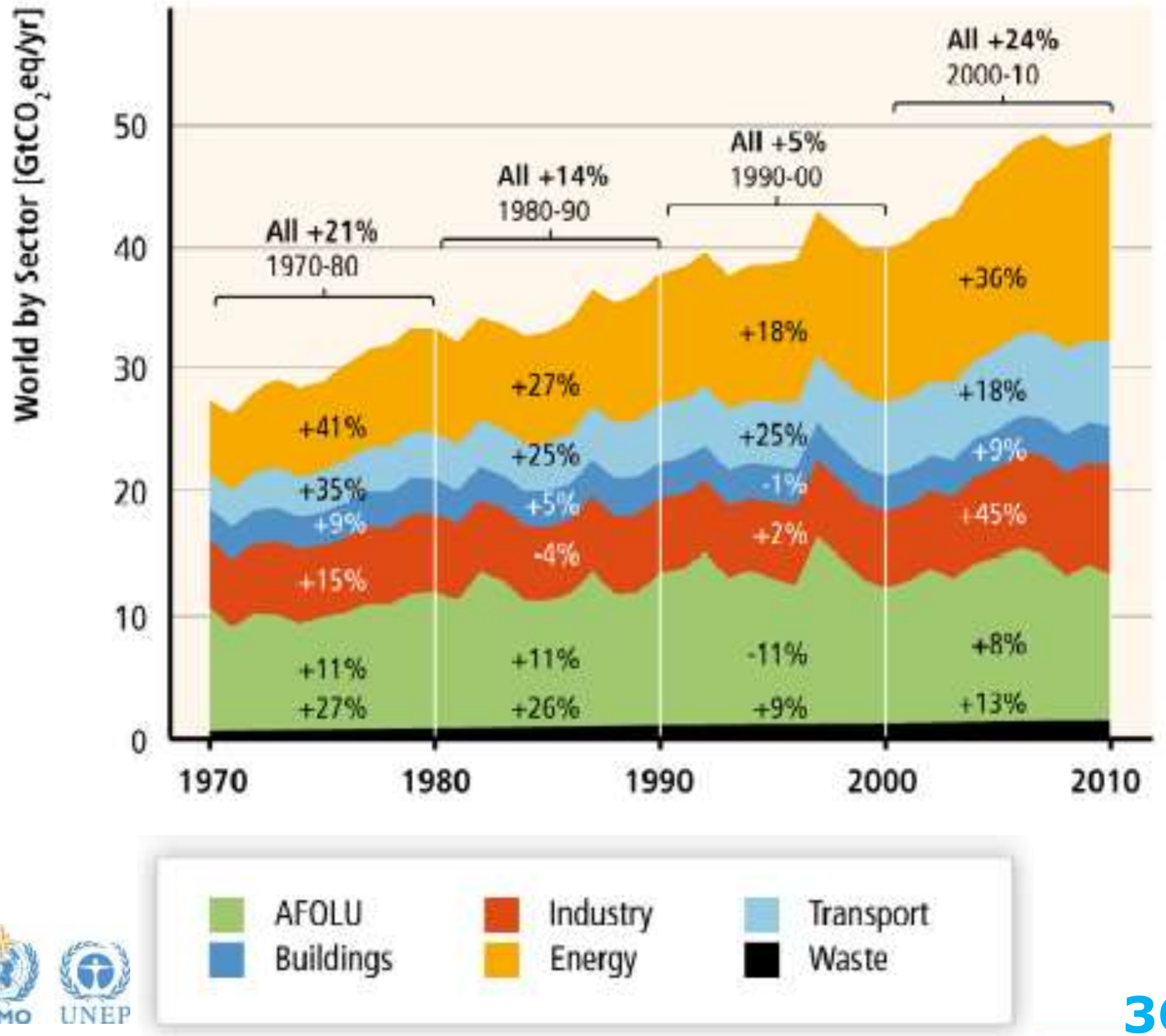
Allocation of Electricity/Heat Generation Emissions to End-use Sectors for 2010



Source: Figure A.II.2

Historical development of emissions by sector (fig 5.18)

(note: direct emissions only)



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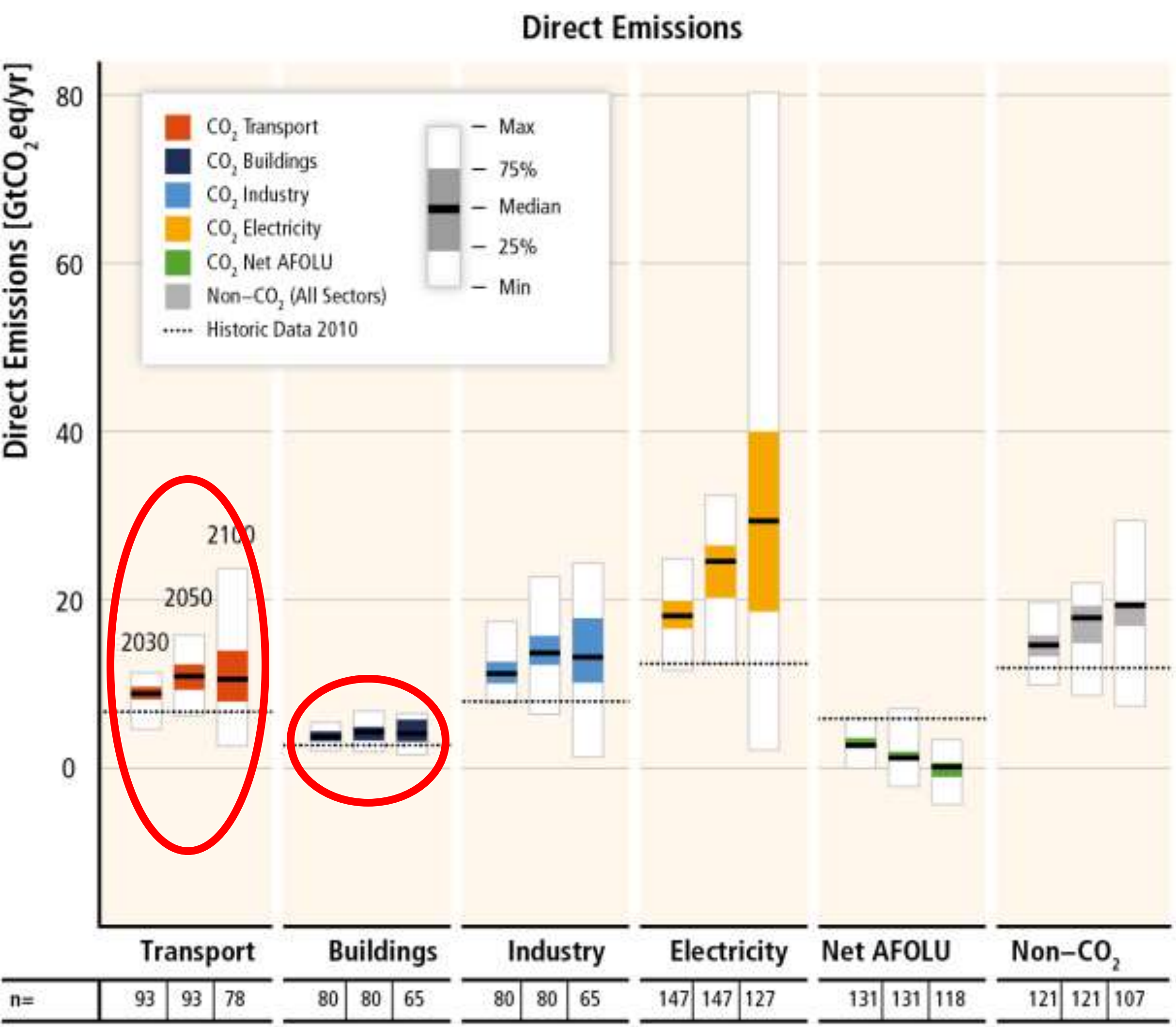
Baseline Scenarios: Direct vs. Indirect Emission Accounting



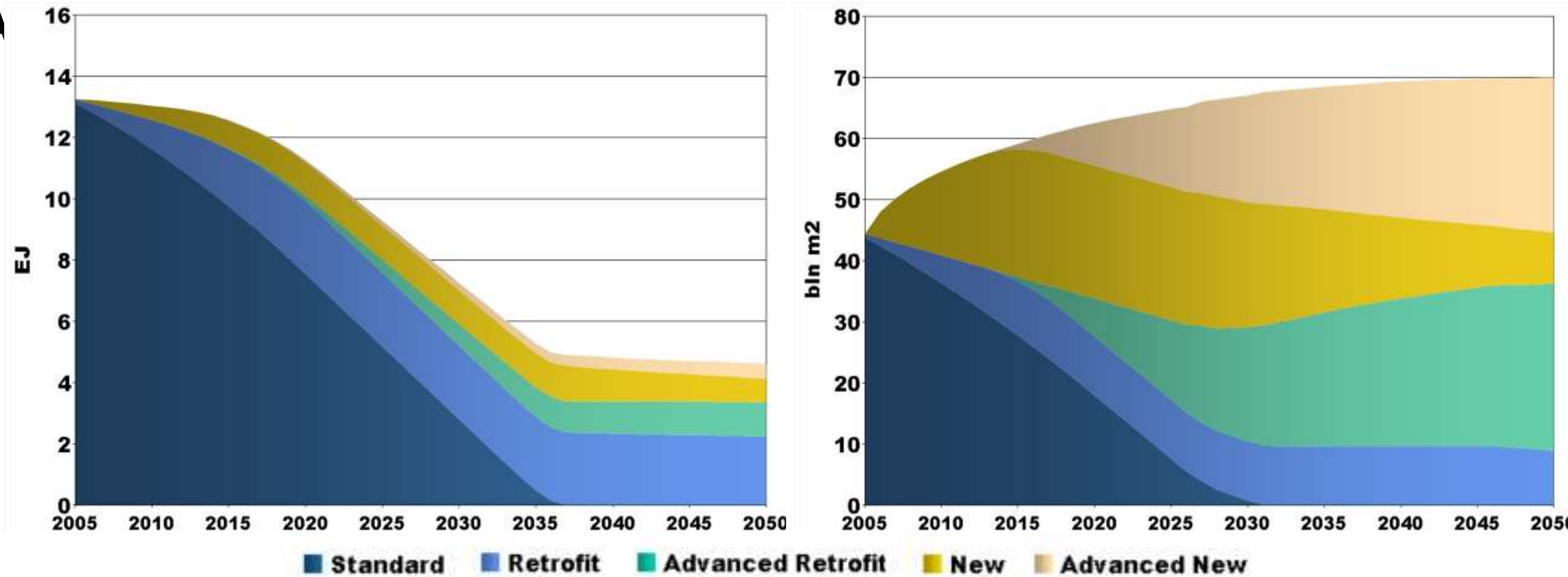
Source: Figure SPM.10, TS.15

Importance of building sector emissions

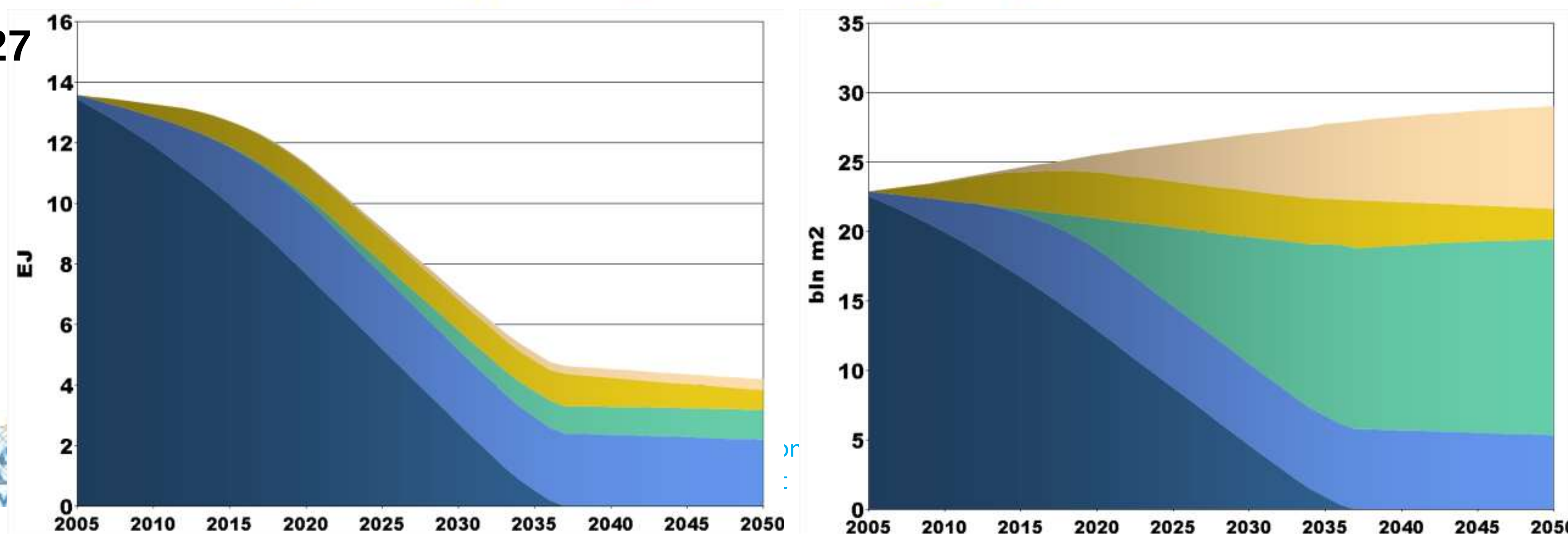
- In developed countries most future building emissions can be affected by retrofits….
- …while in developing countries through new construction.

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

USA



EU-27



Lesson #2: importance of retrofits

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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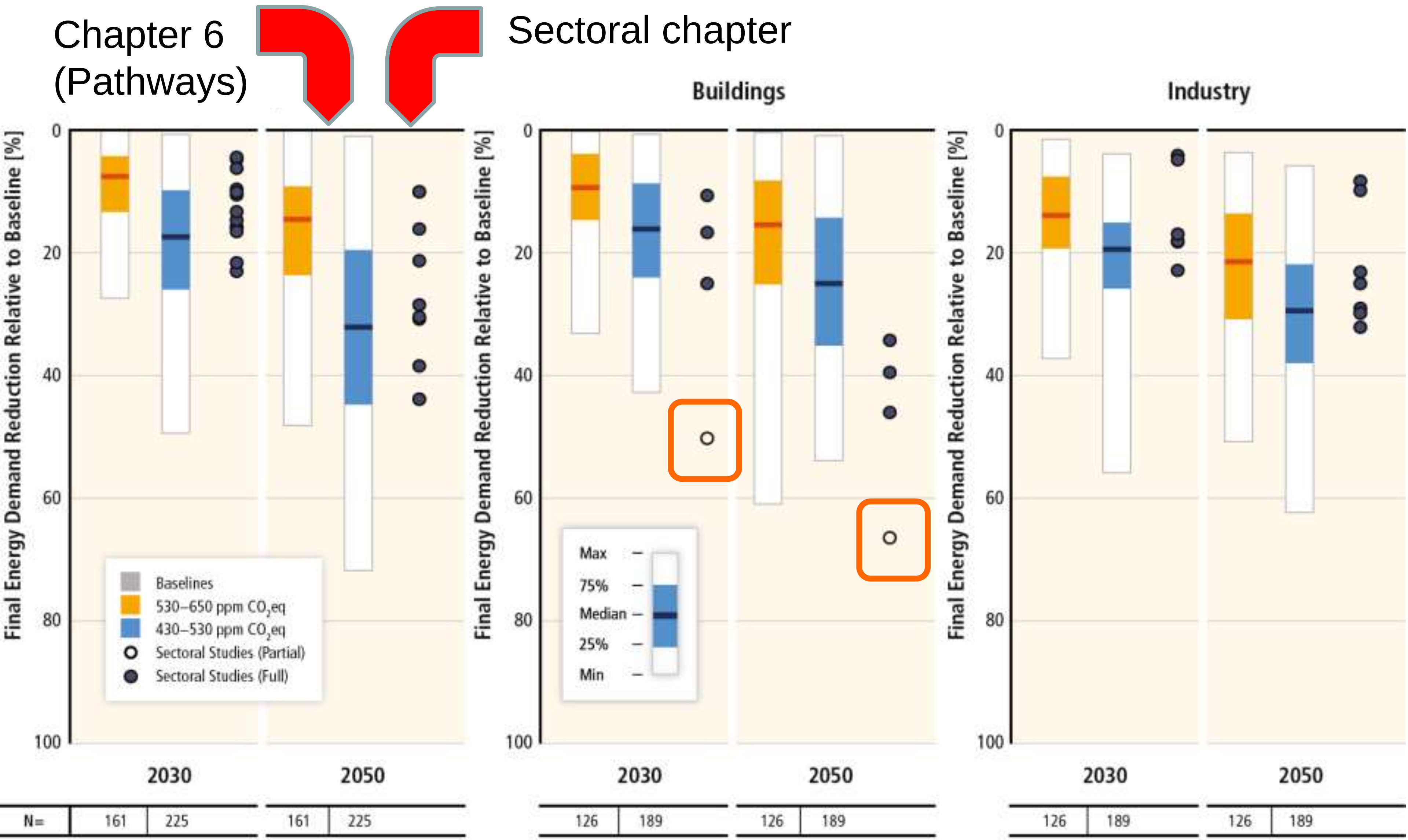
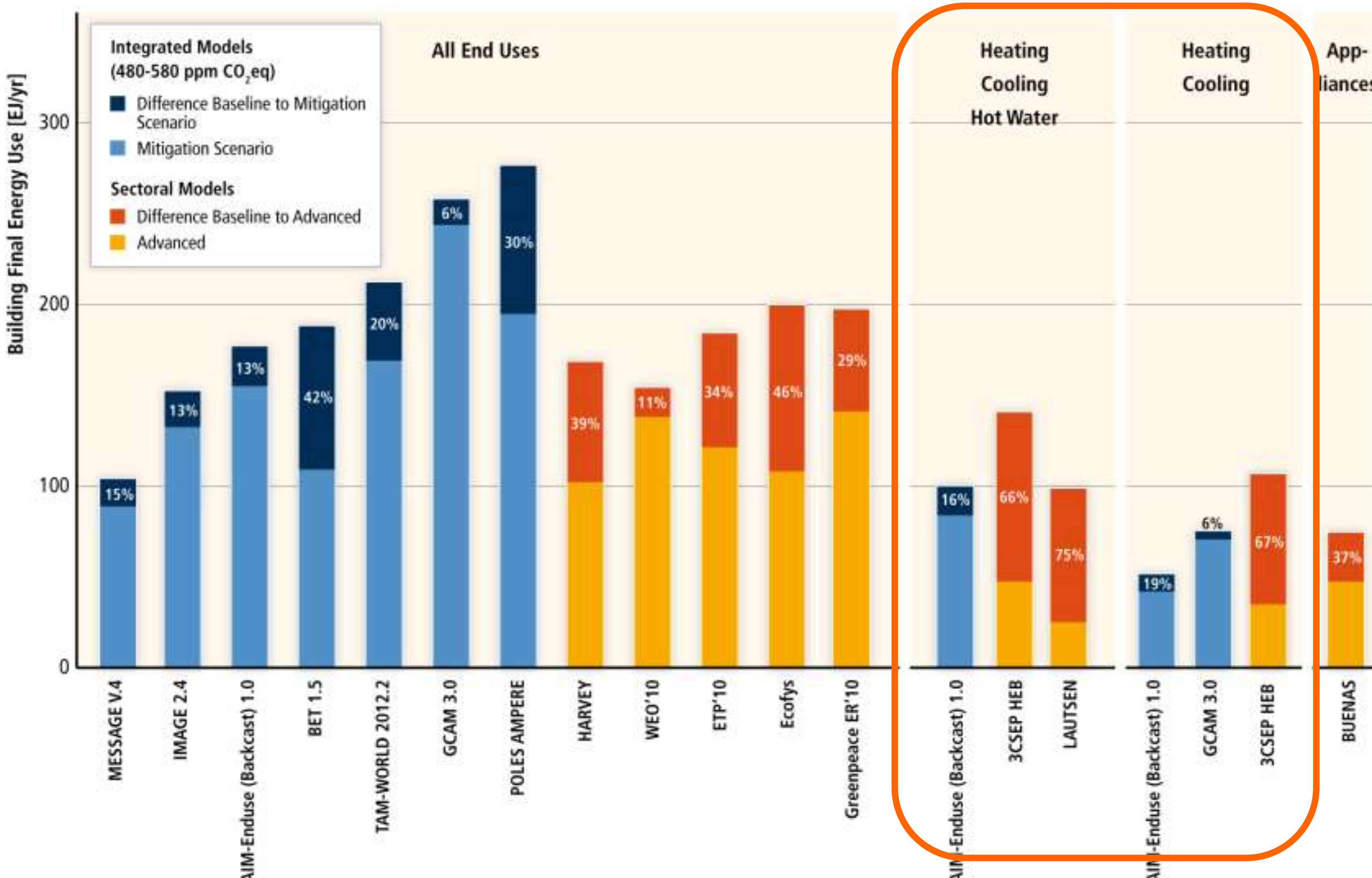
Energy Demand Reduction Potential



Source: Figure SPM.11

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



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

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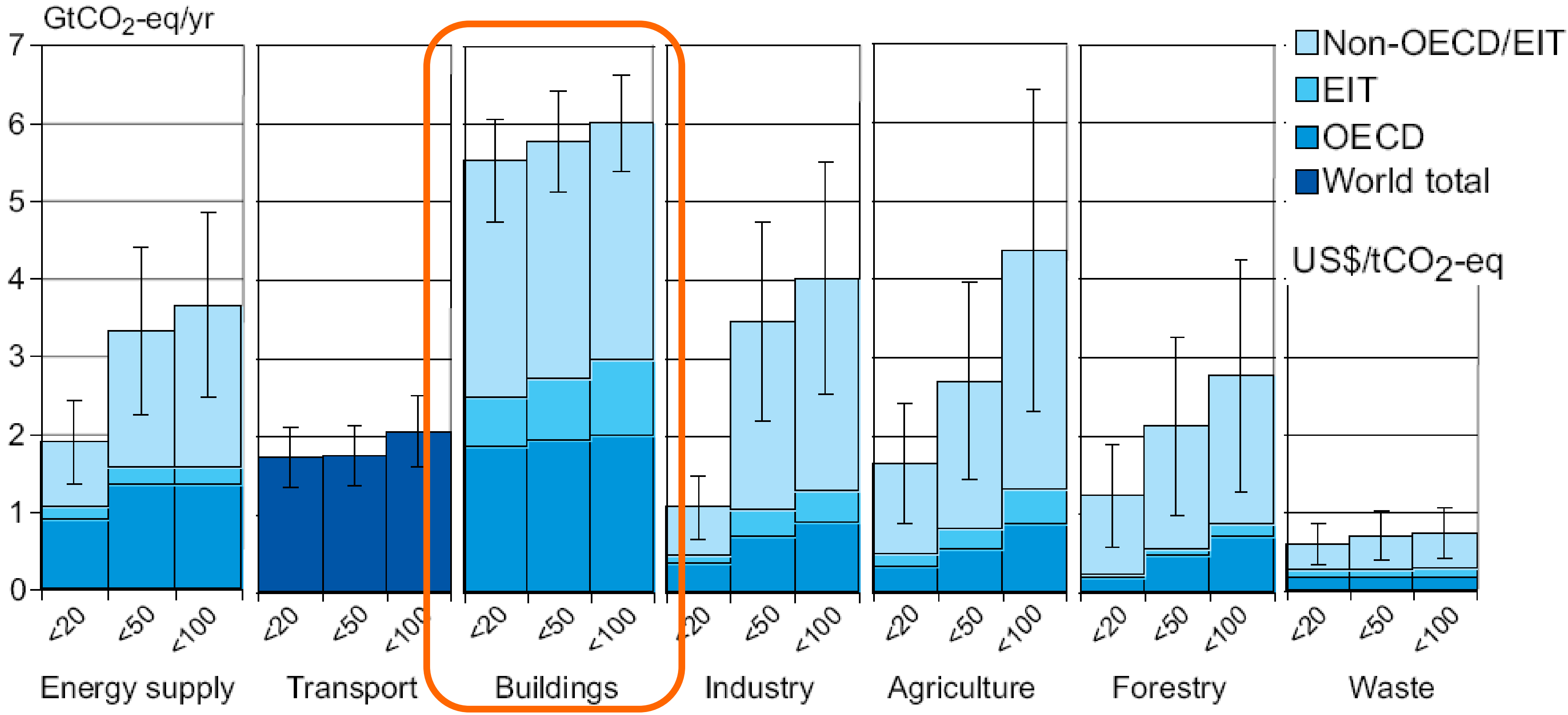
AR4: The buildings sector offers the largest low-cost potential in all world regions by 2030



(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

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

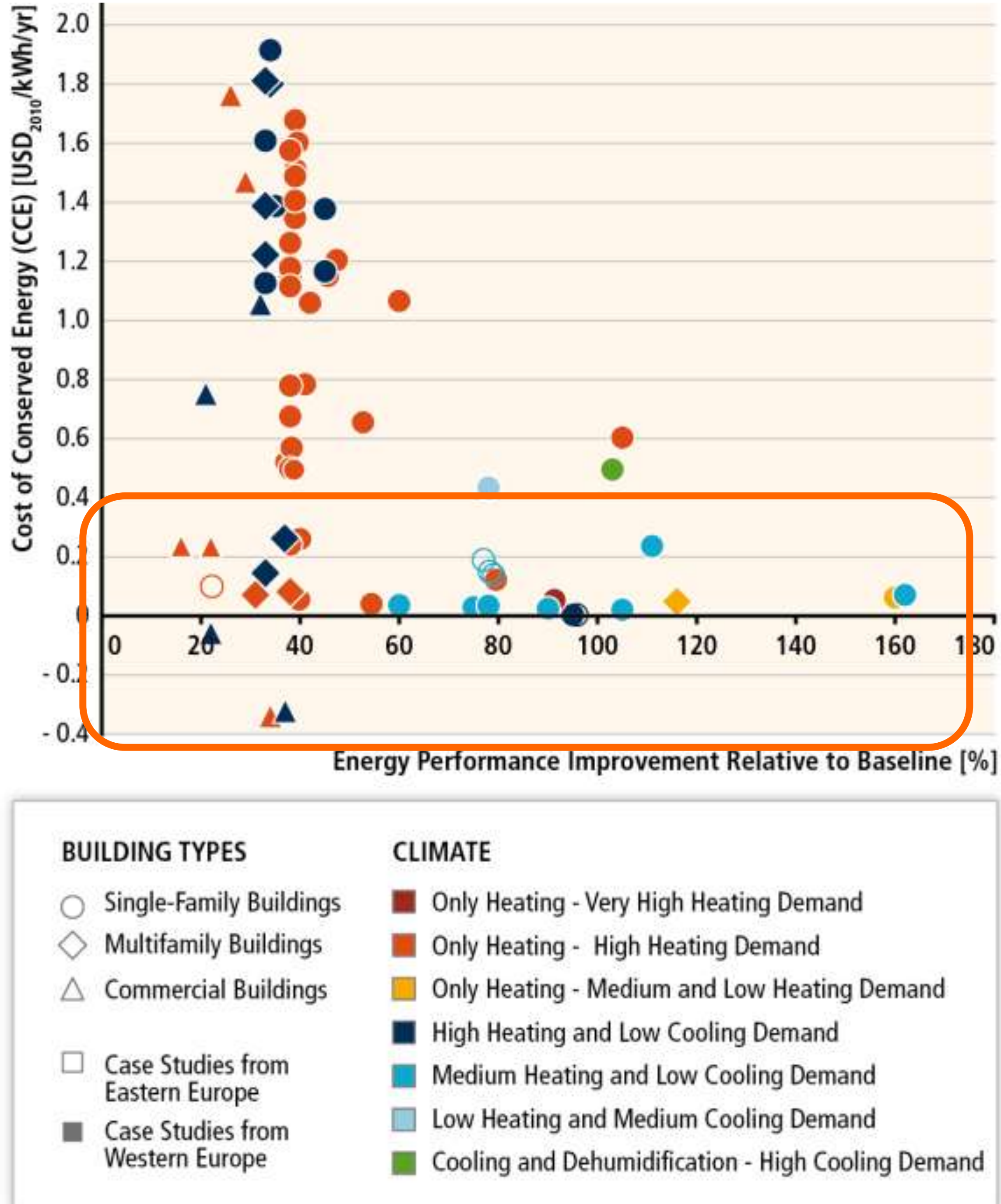


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Figure 9.15. Cost of conserved carbon as a function of specific energy consumption for selected
best practices shown in Figure 9.14.

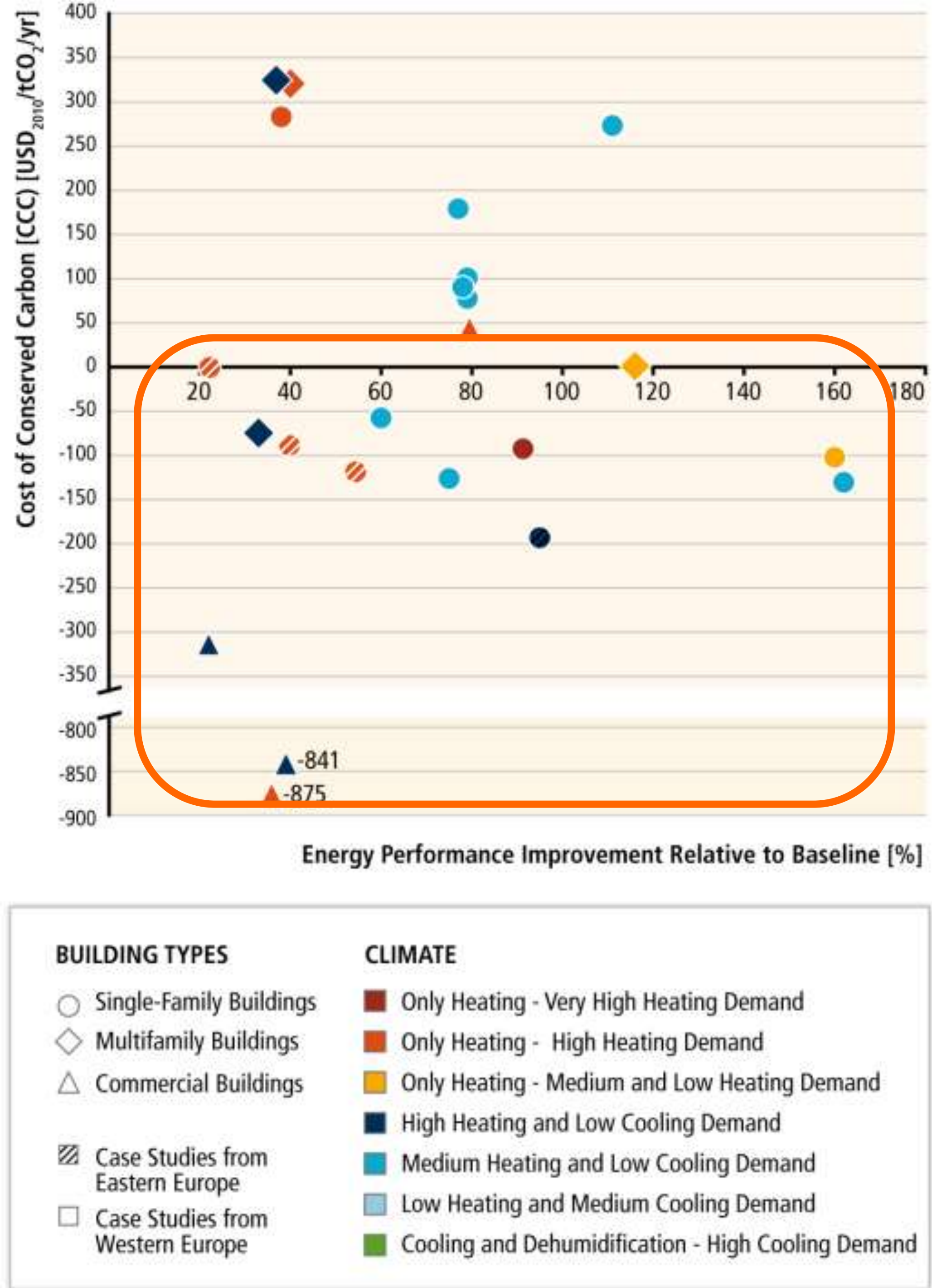
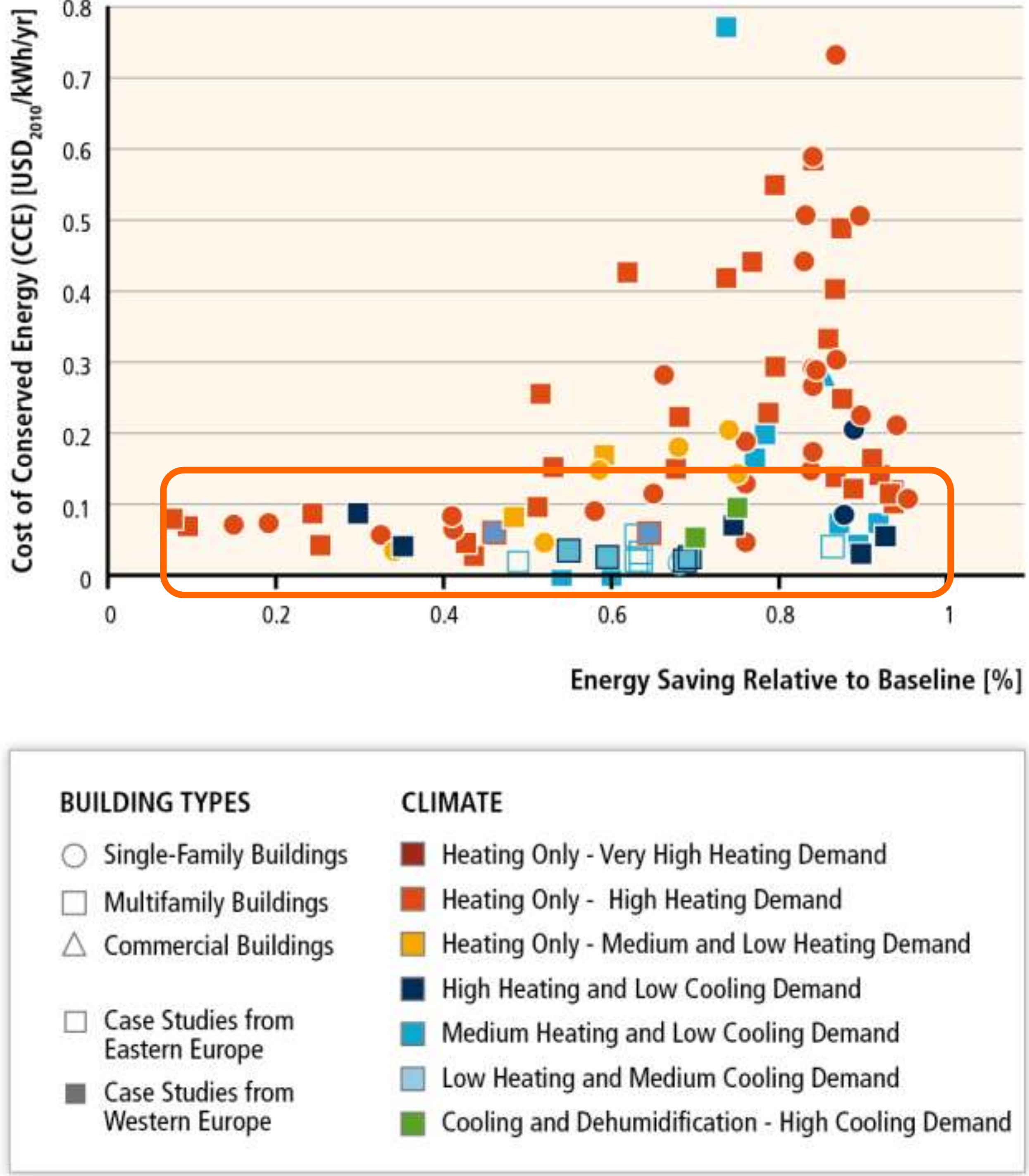


Figure 9.16. Cost of conserved energy as a function of energy saving in percent for European retrofitted buildings by building type and climate zones.



4. In addition, they have high co-benefits

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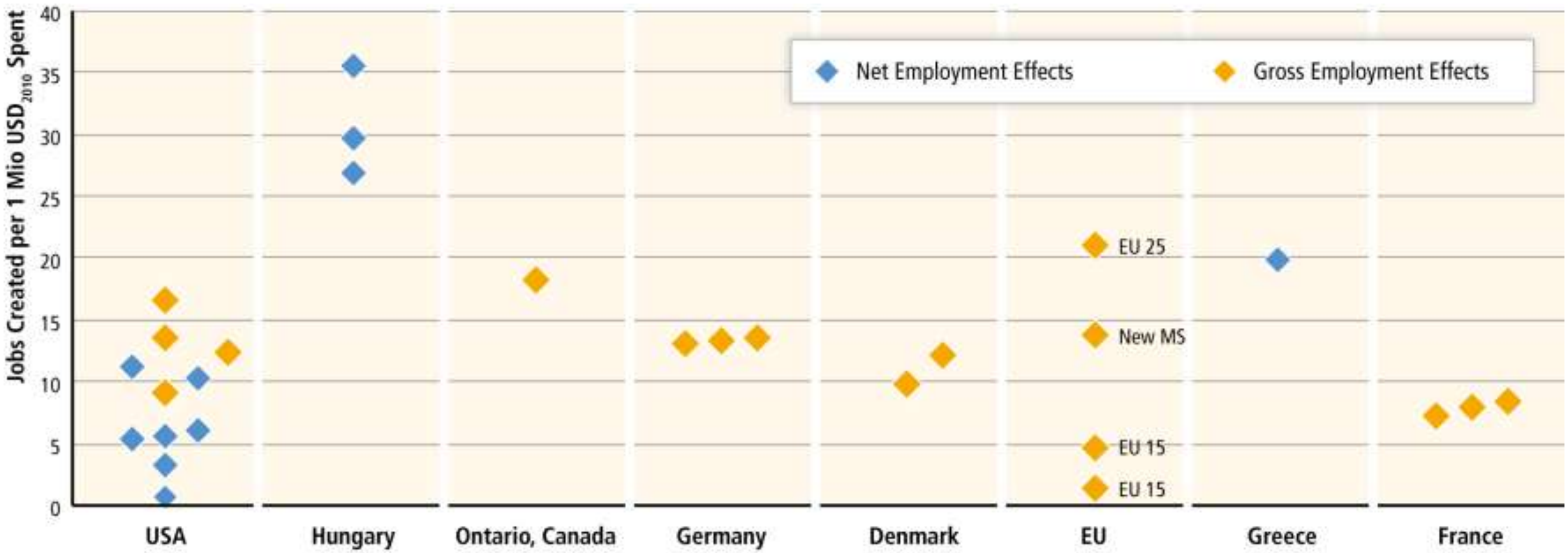
"Overall, the potential for co-benefits for energy end-use measures outweigh the potential for adverse side-effects, whereas the evidence suggests this may not be the case for all energy supply and AFOLU measures." (SPM 4.1)

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

Buildings	/concerns		dditional objectives/
	Environmental	Other	cial
			e 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) en/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 n) rofits and exemplary new en 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)		

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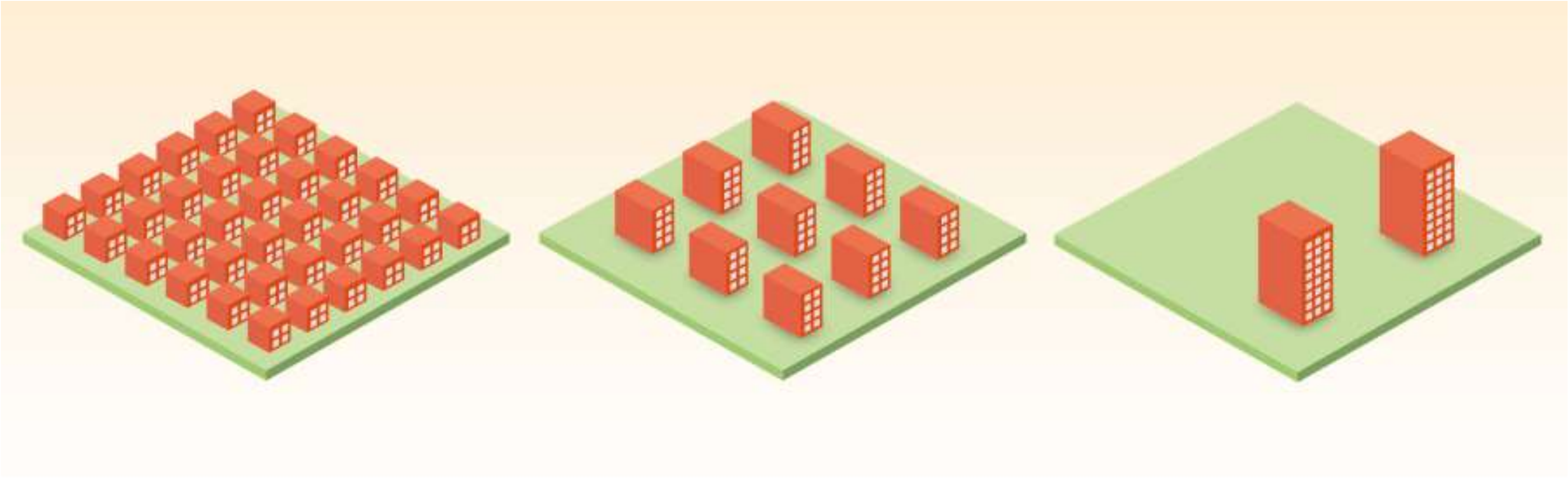
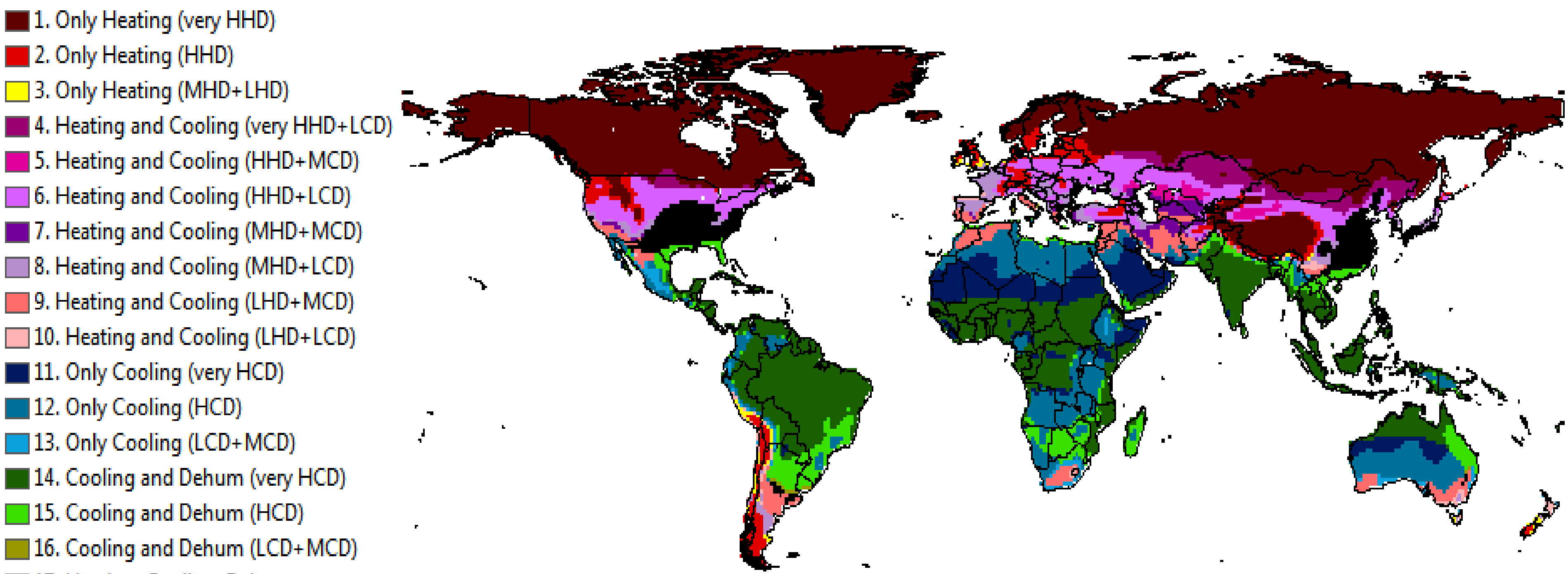
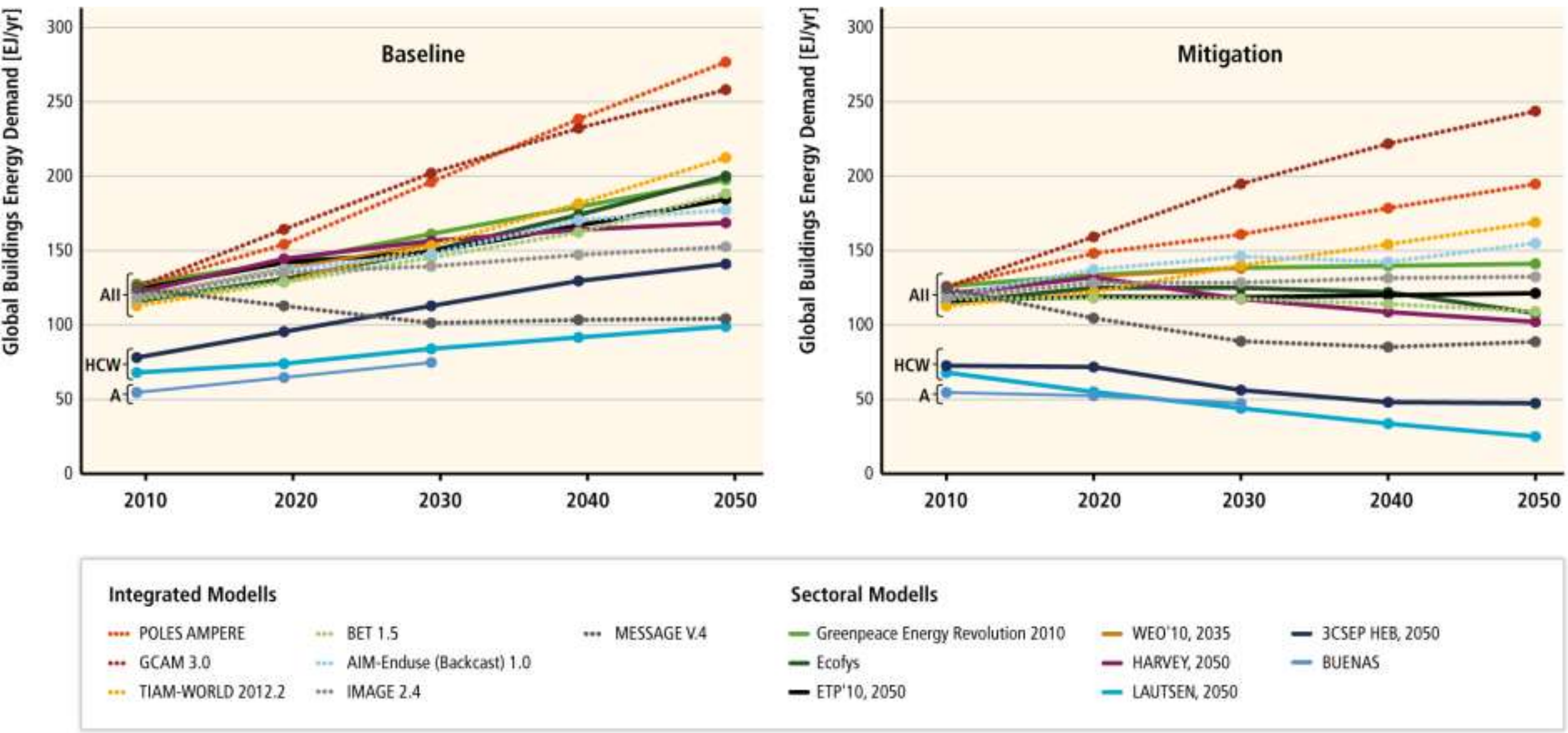
"Infrastructure developments and long-lived products that lock societies into GHG-intensive emissions pathways may be difficult or very costly to change, reinforcing the importance of early action for ambitious mitigation" (SPM 4.2)

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



Climate Types





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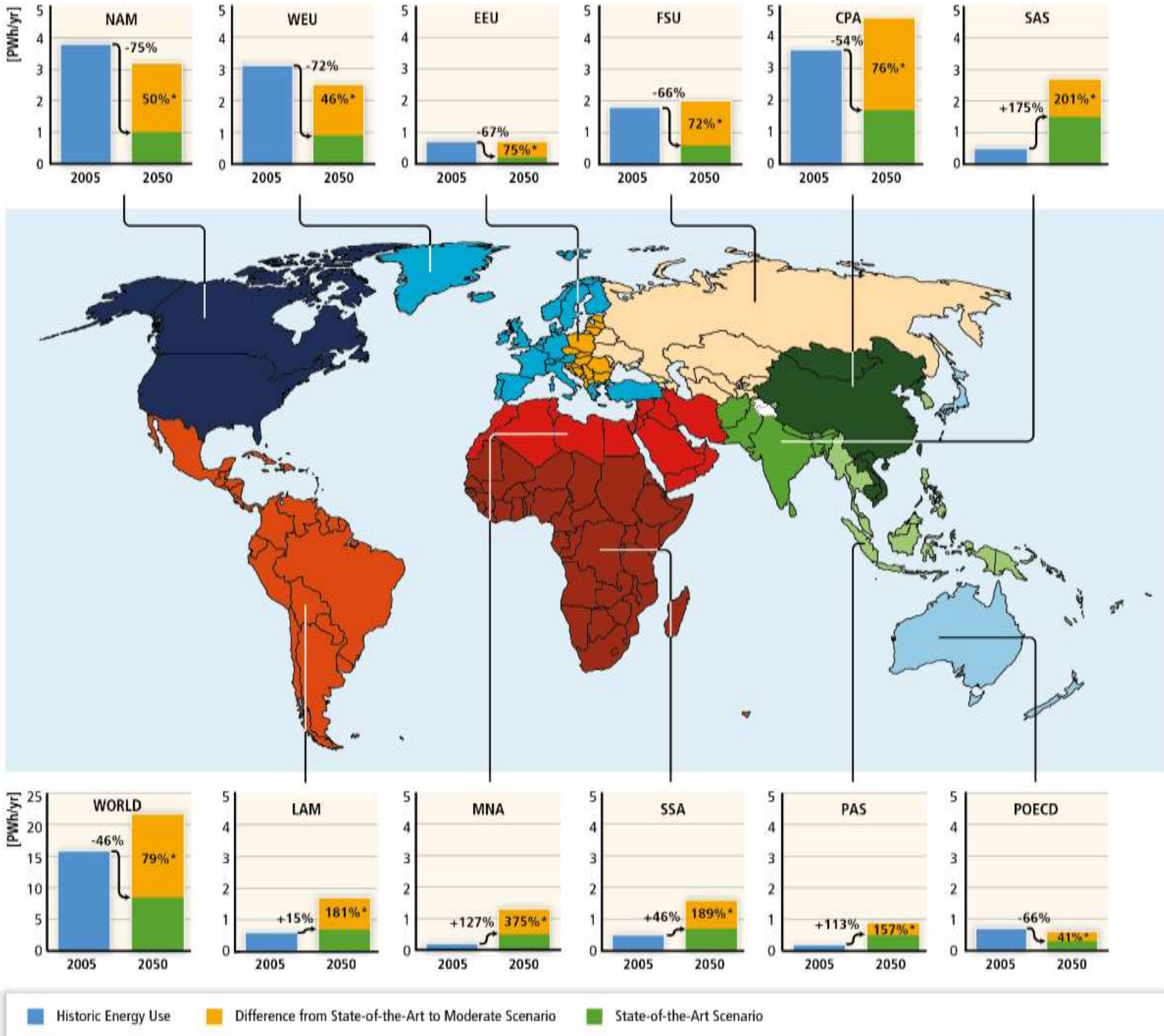
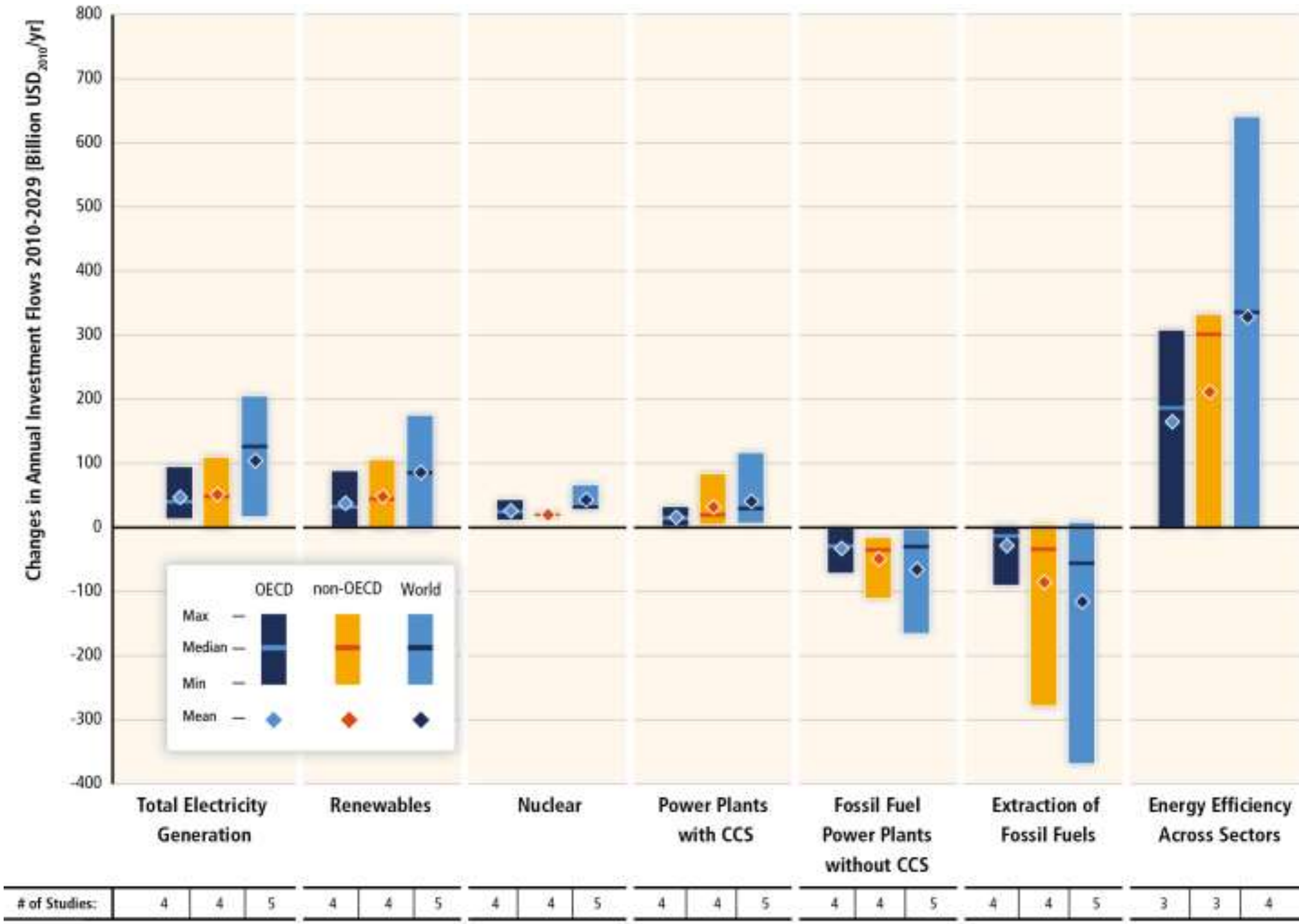


*Lock-in Risk of Sub-Optimal Scenario Realative to Energy Use in 2005.

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



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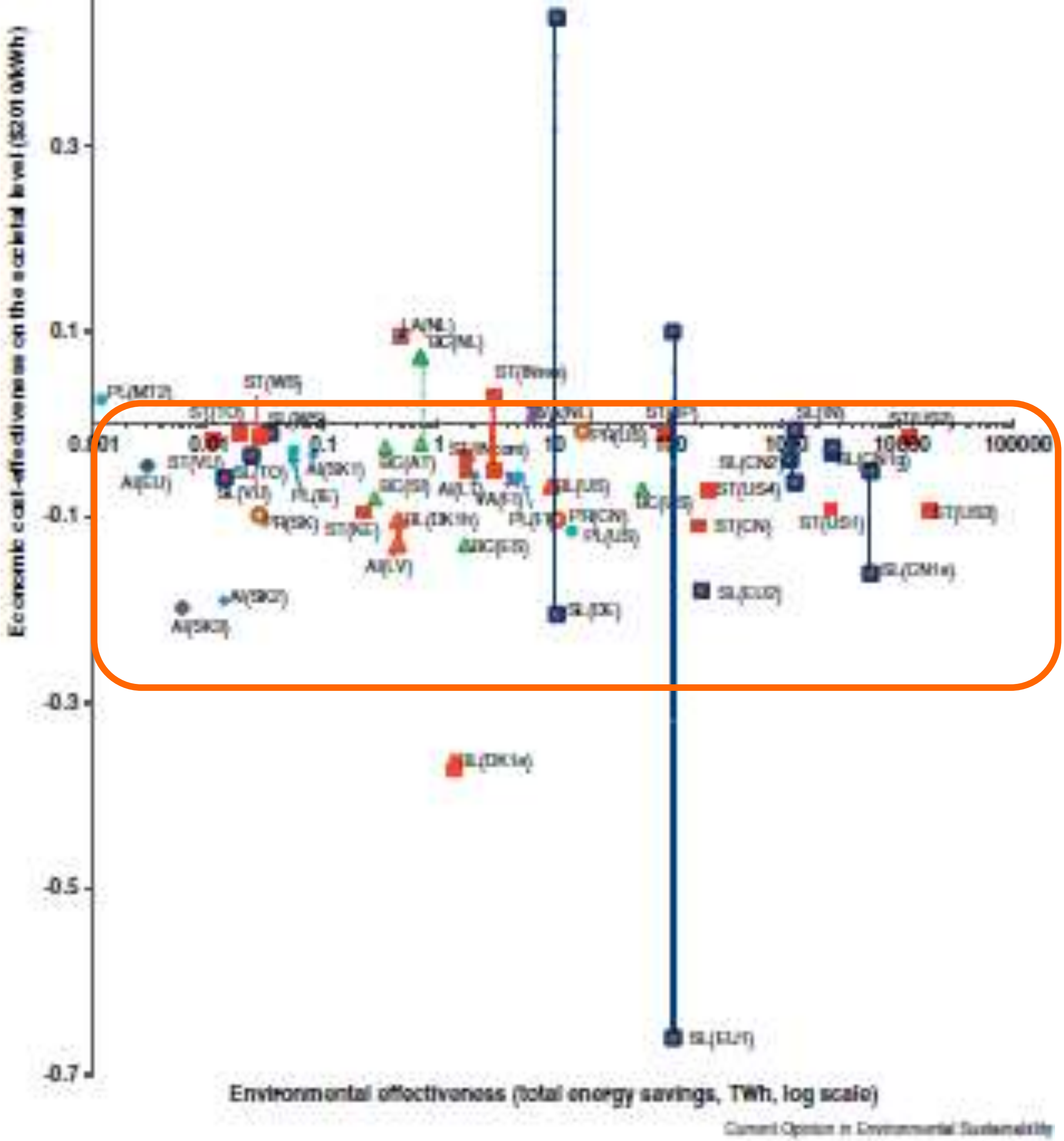
Cost of conserved carbon for implemented energy efficiency programs, post-ante evaluation results (based on data in Table 9.9 (boza-kiss et.al 2013 in COSUst)



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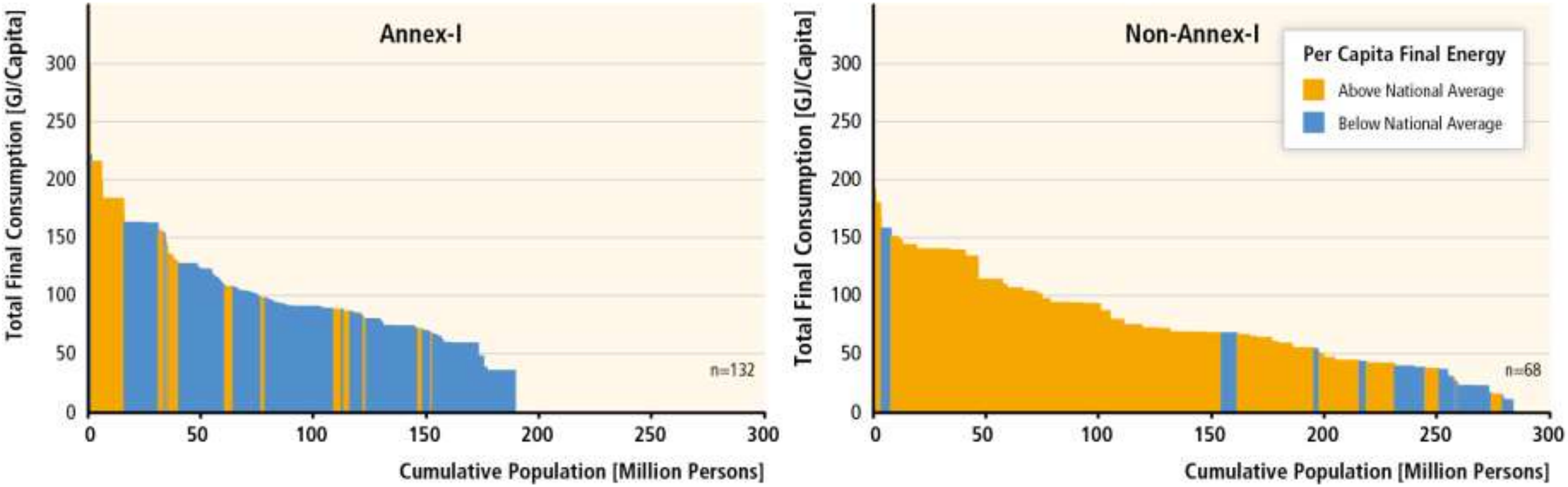
Key Message 1: Urban areas are focal points of energy use and CO_2 emissions

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



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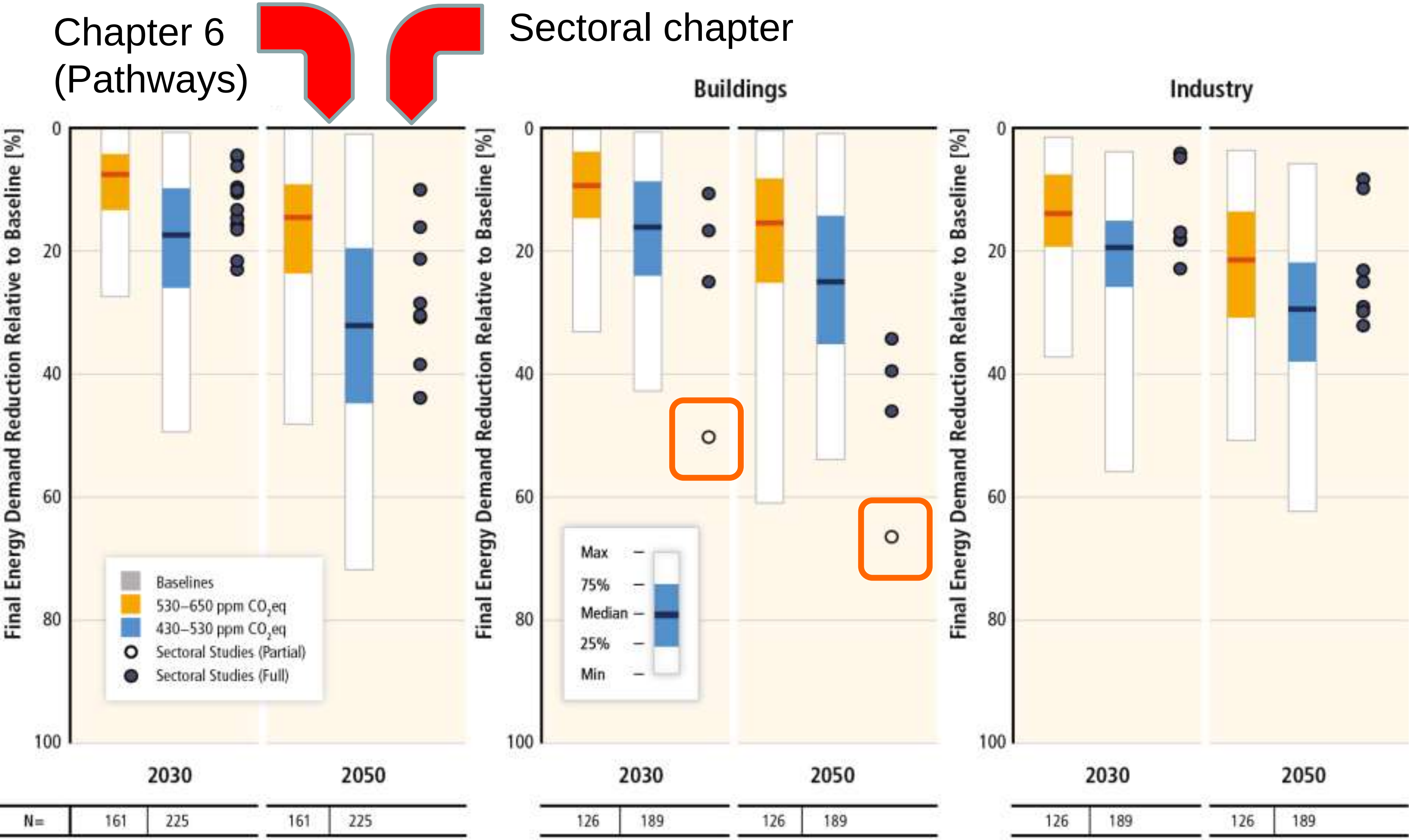
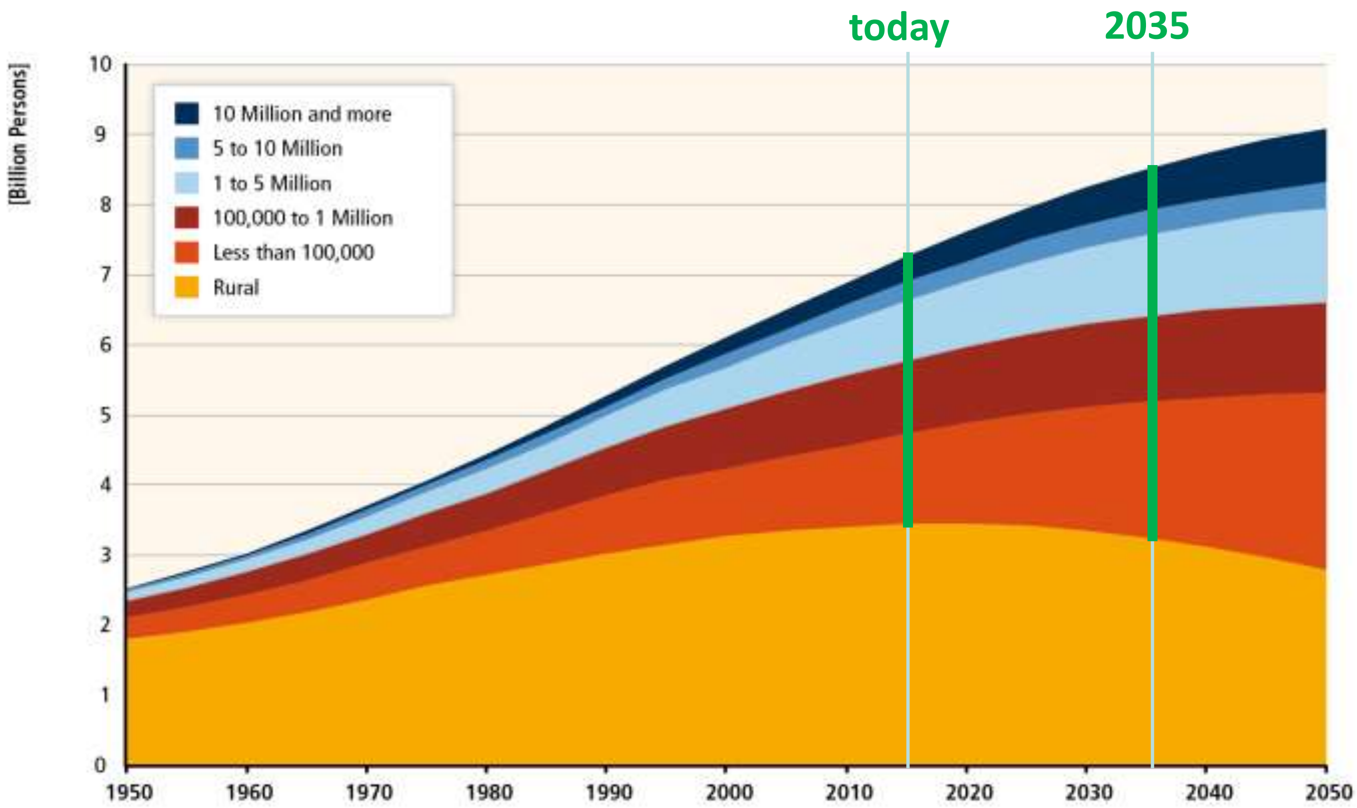
Energy Demand Reduction Potential



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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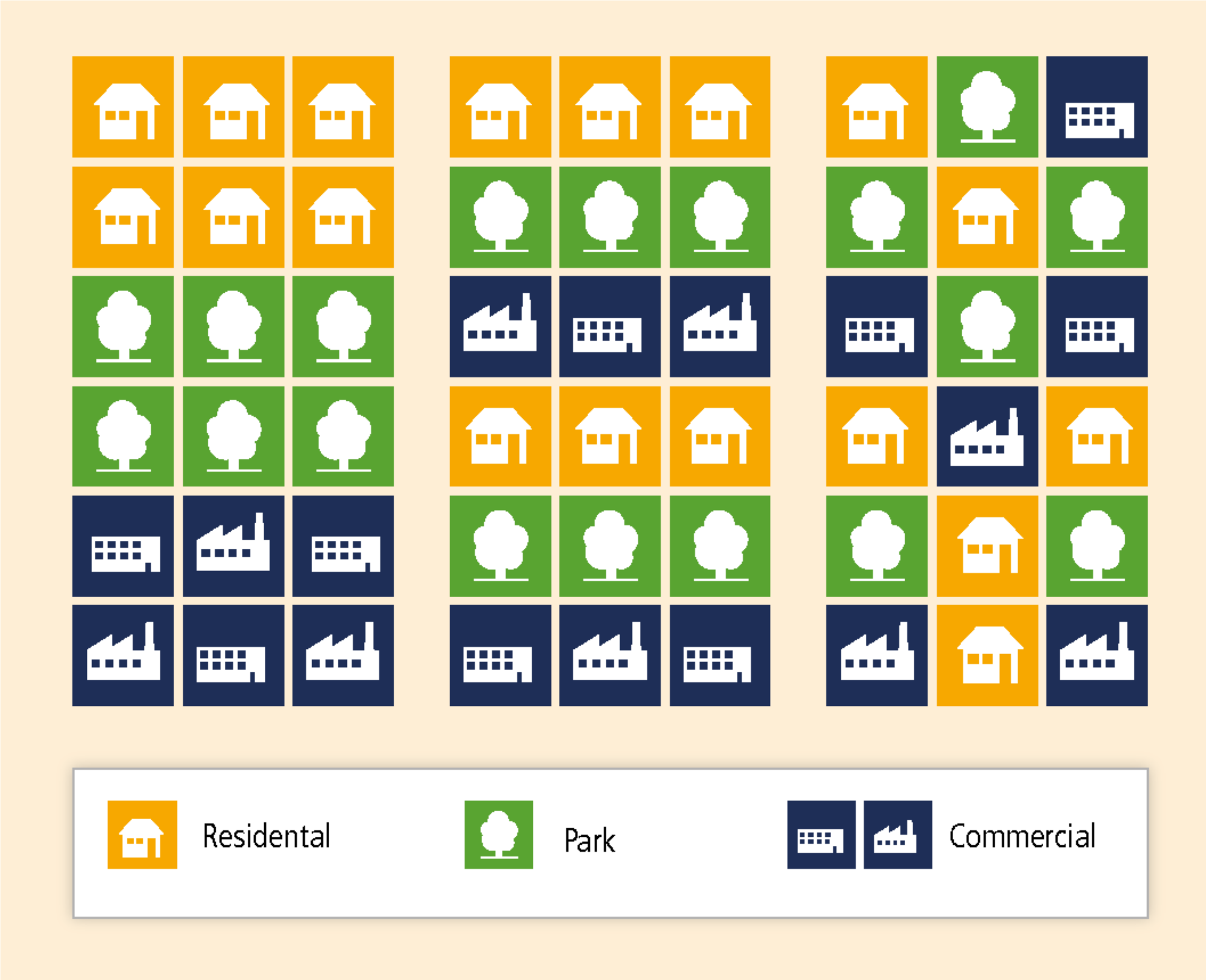
To lower urban emissions, need diverse urban land use mix



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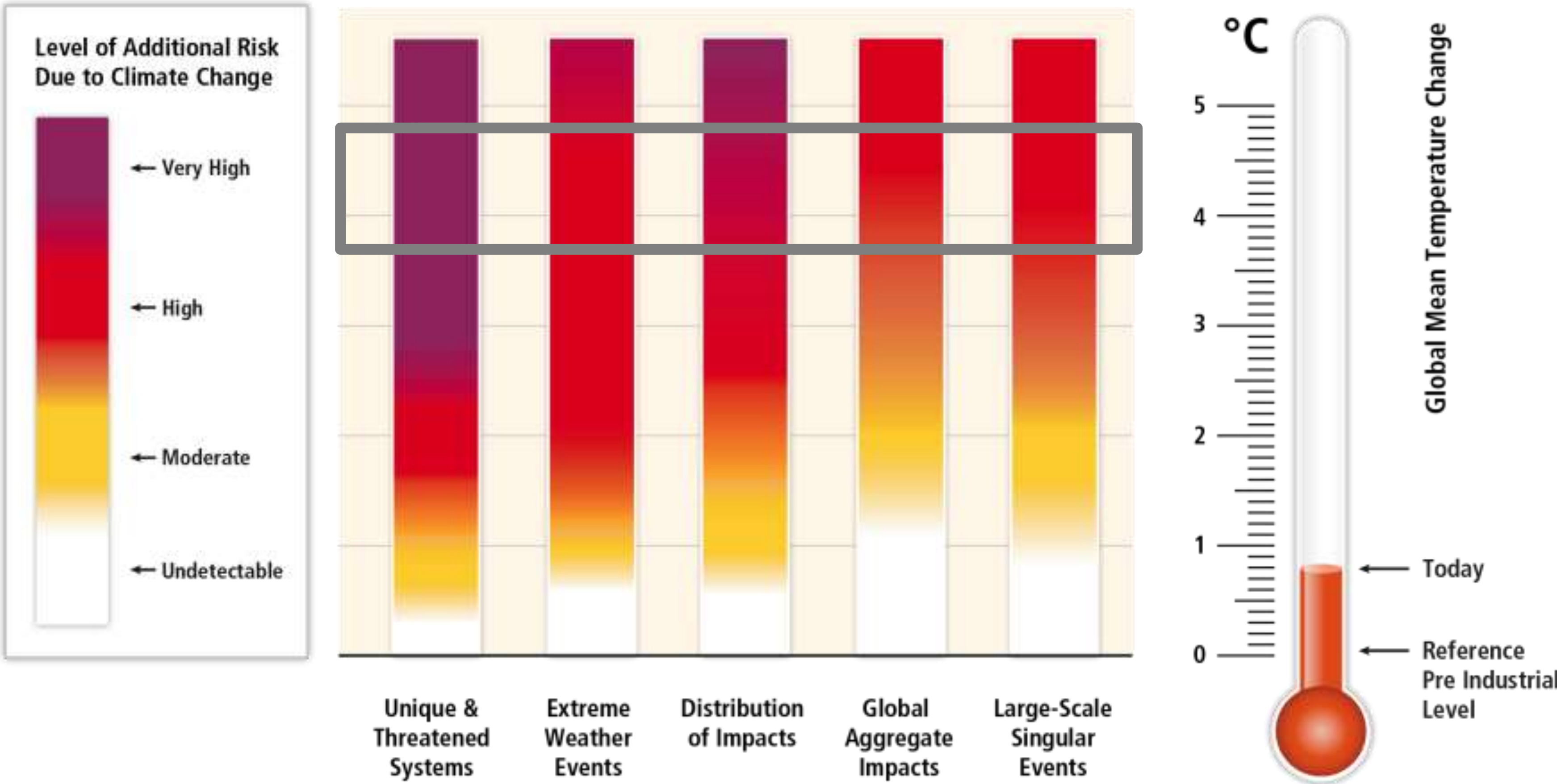
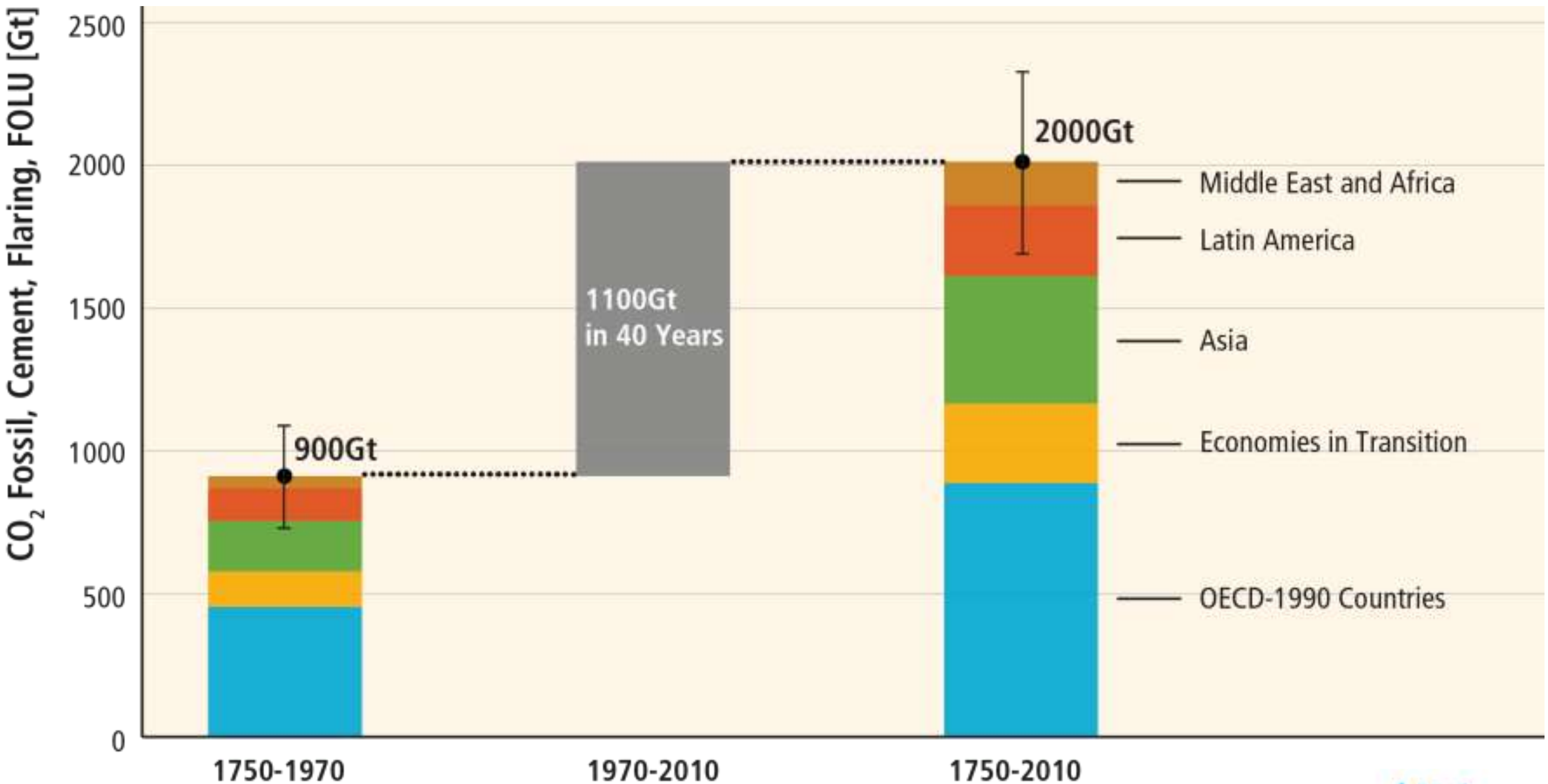
Without additional mitigation, global mean surface temperature is projected to increase by 3.7 to 4.8°C over the 21st century.



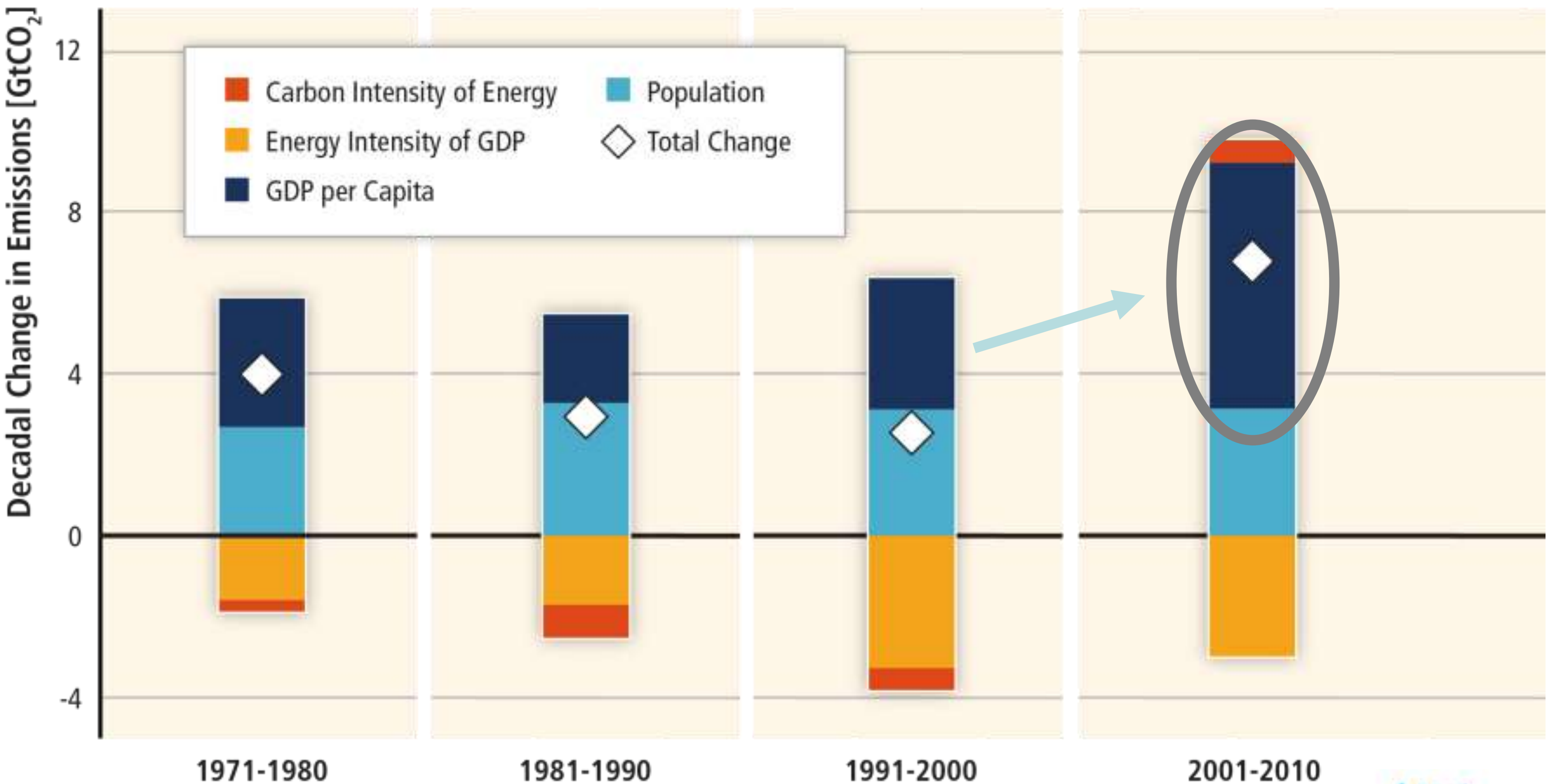
Based on WGII AR5 Figure 19.4

About half of the cumulative anthropogenic CO_2 emissions between 1750 and 2010 have occurred in the last 40 years.



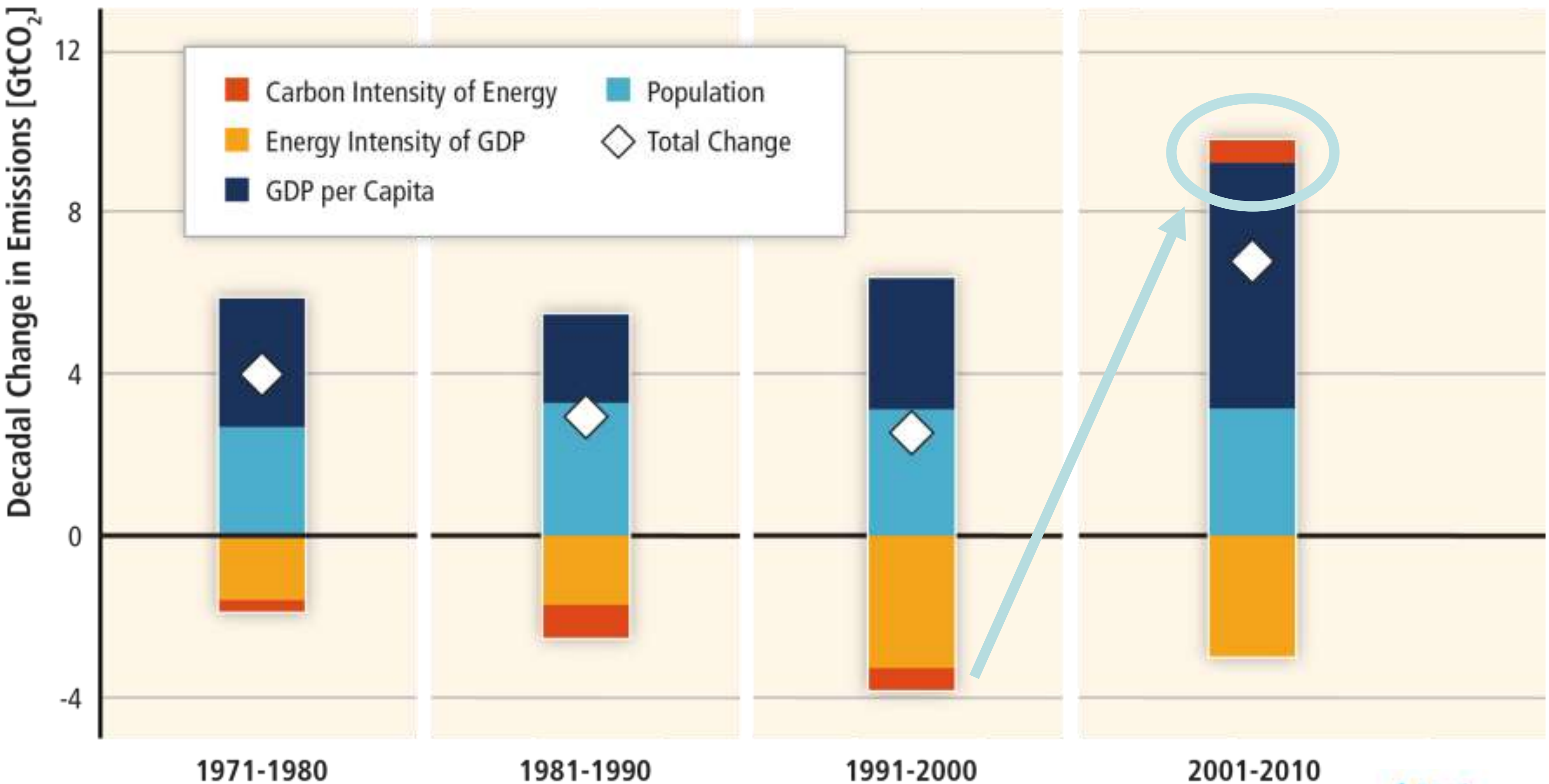
Based on Figure 5.3

GHG emissions rise with growth in GDP and population.



Based on Figure 1.7

The long-standing trend of decarbonisation has reversed.

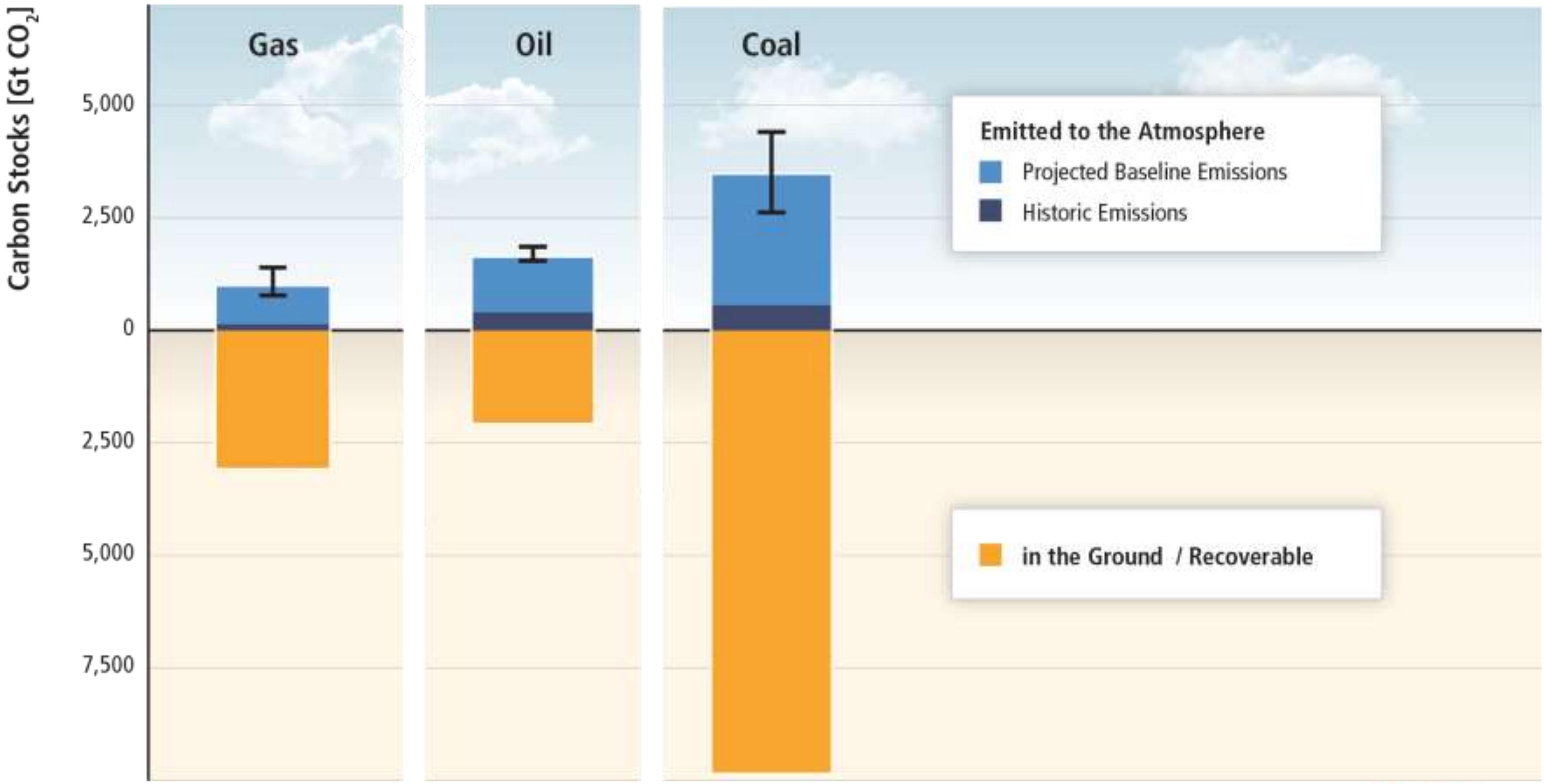


Based on Figure 1.7

Working Group III contribution to the
IPCC Fifth Assessment Report

3CSEP

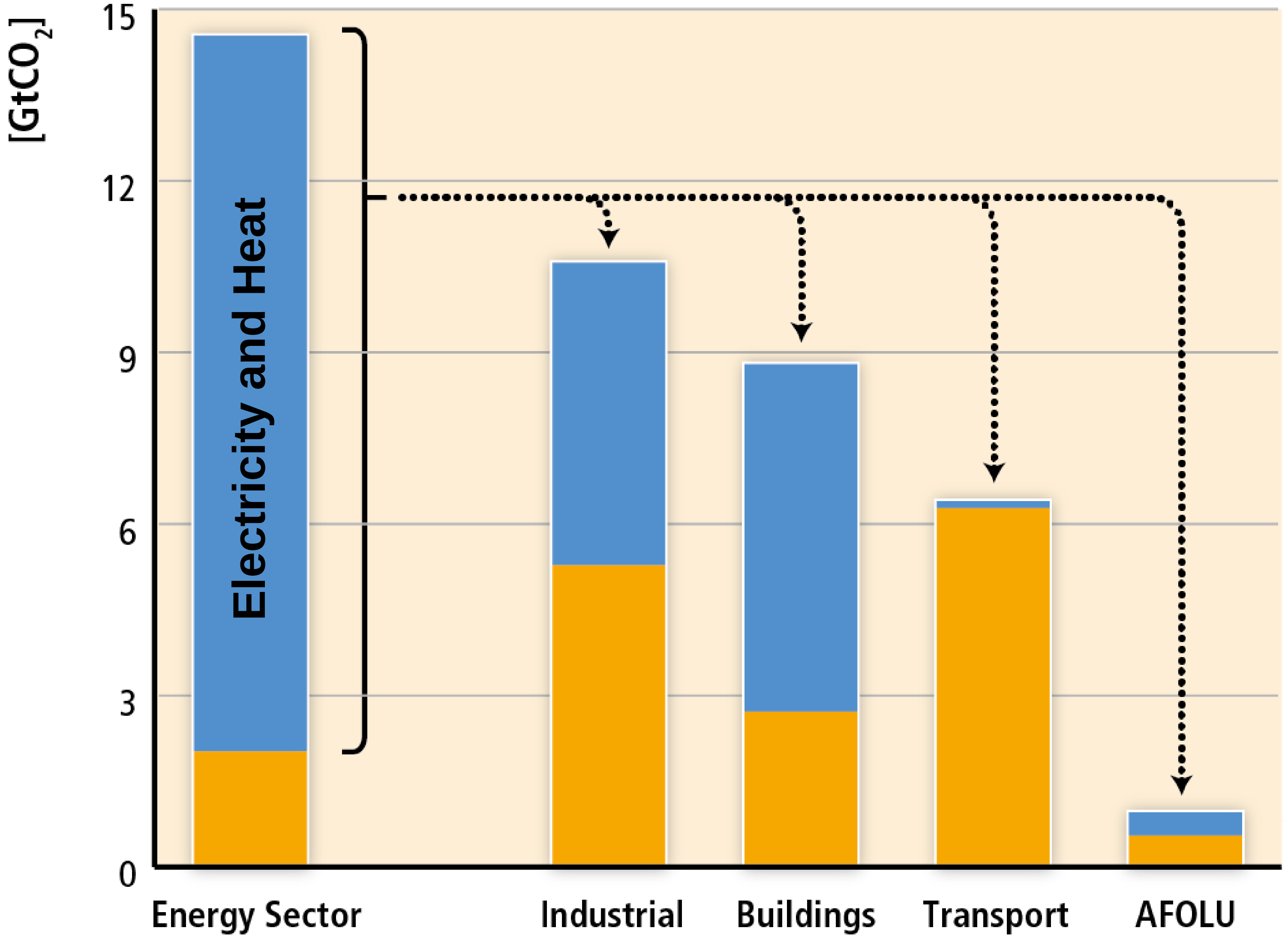
There is far more carbon in the ground than emitted in any baseline scenario.



Based on SRREN Figure 1.7


Climate change is a global commons problem.

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

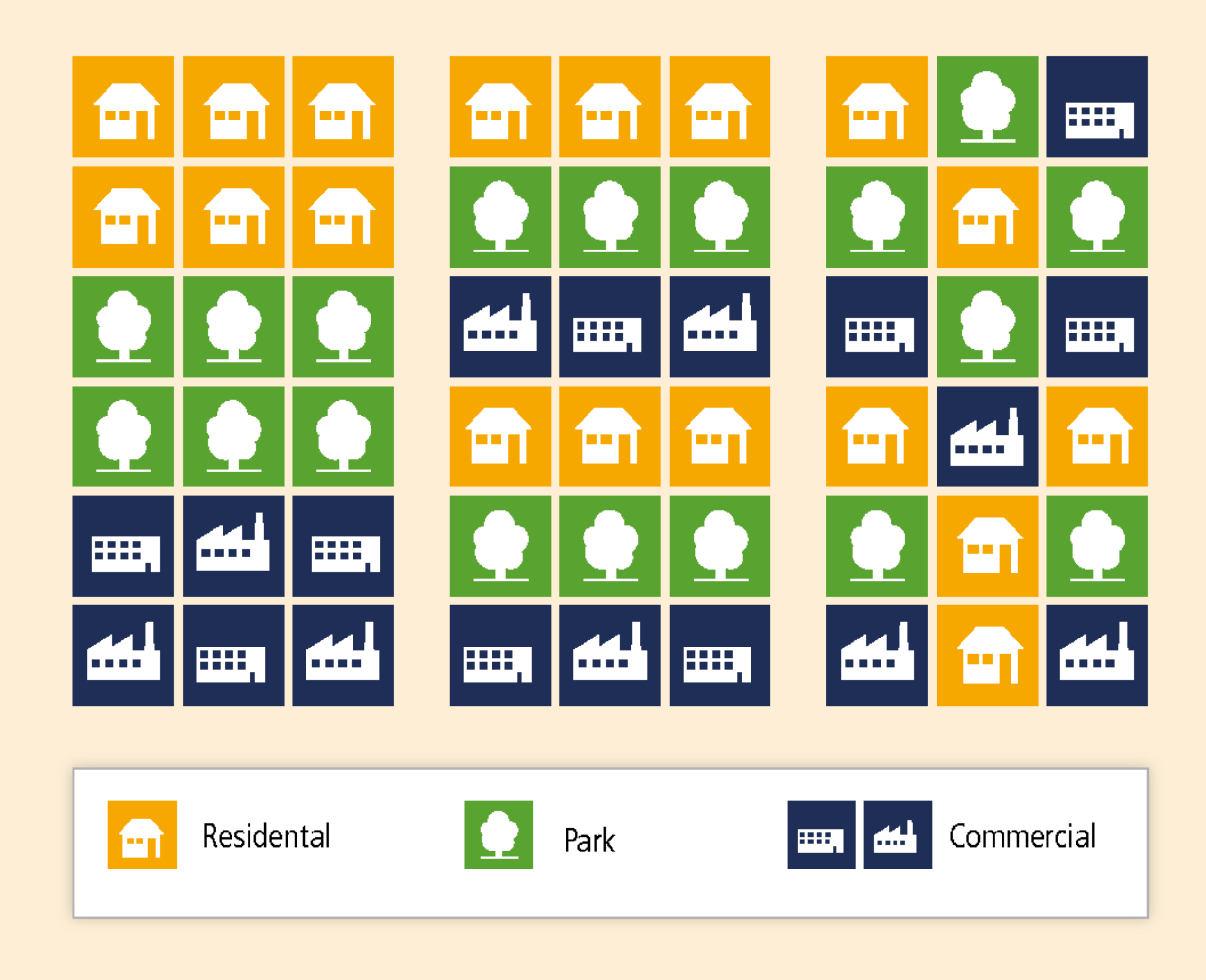


Source: Figure A.II.2

Industry I

- **From a short and mid-term perspective energy efficiency and behaviour change could significantly contribute to GHG mitigation**
  - The energy intensity of the industry sector could be directly reduced by up to approximately 25% compared to the current level through the wide-scale deployment of best available technologies, upgrading/replacement, particularly in countries where these are not in practice and in non-energy intensive industries
  - Additional energy intensity reductions of up to approximately 20% may potentially be realized through innovation

To lower urban emissions, need diverse urban land use mix



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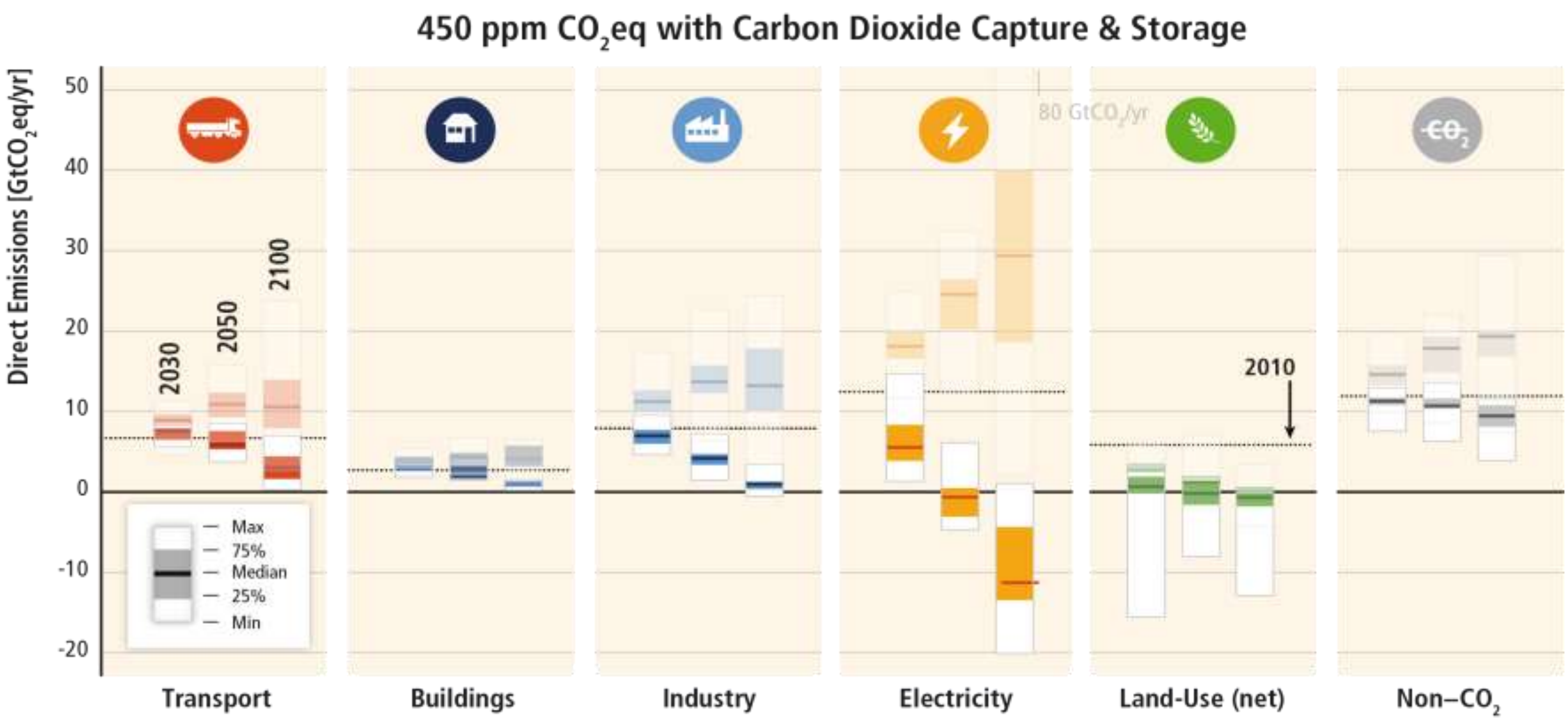
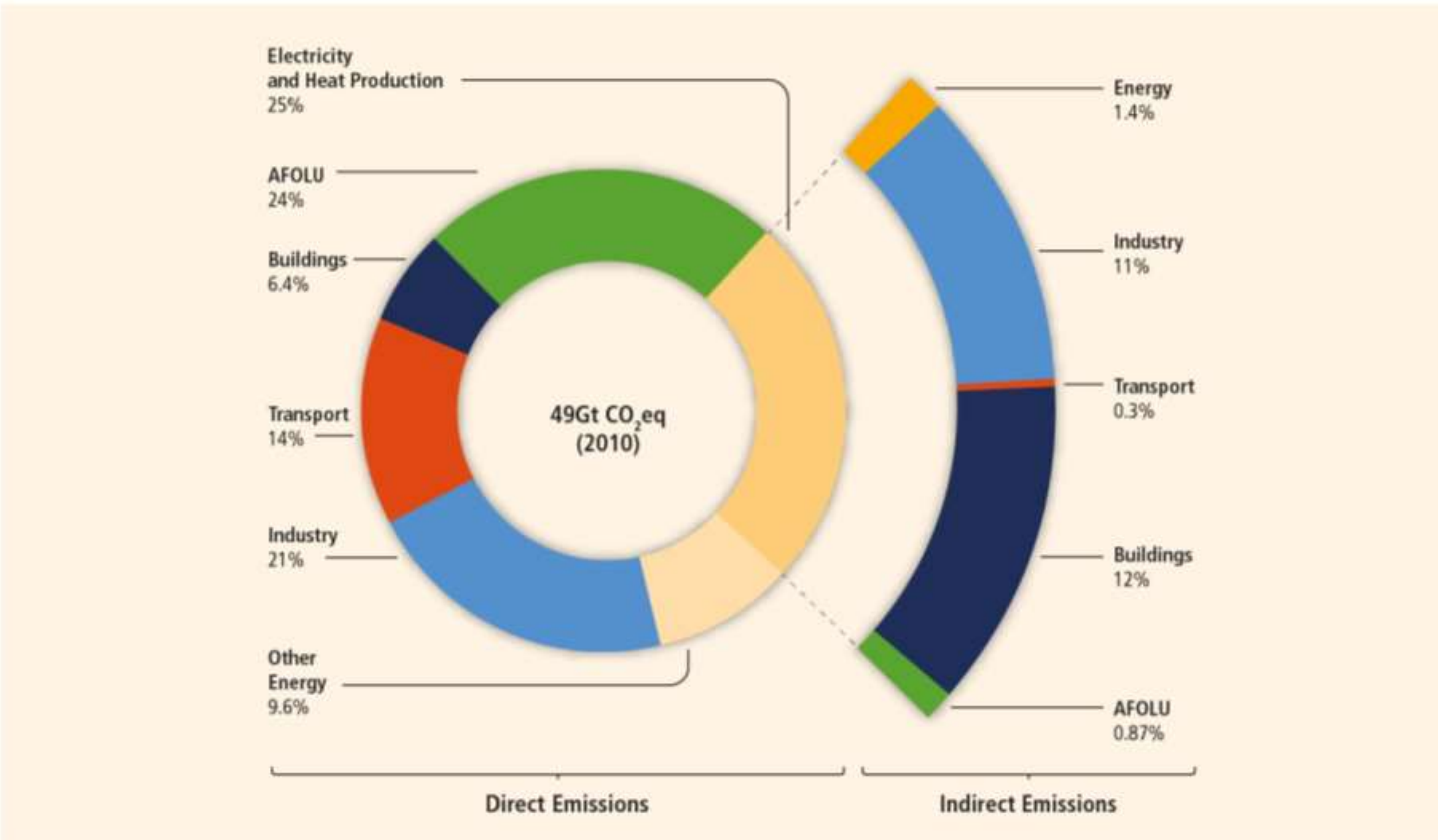
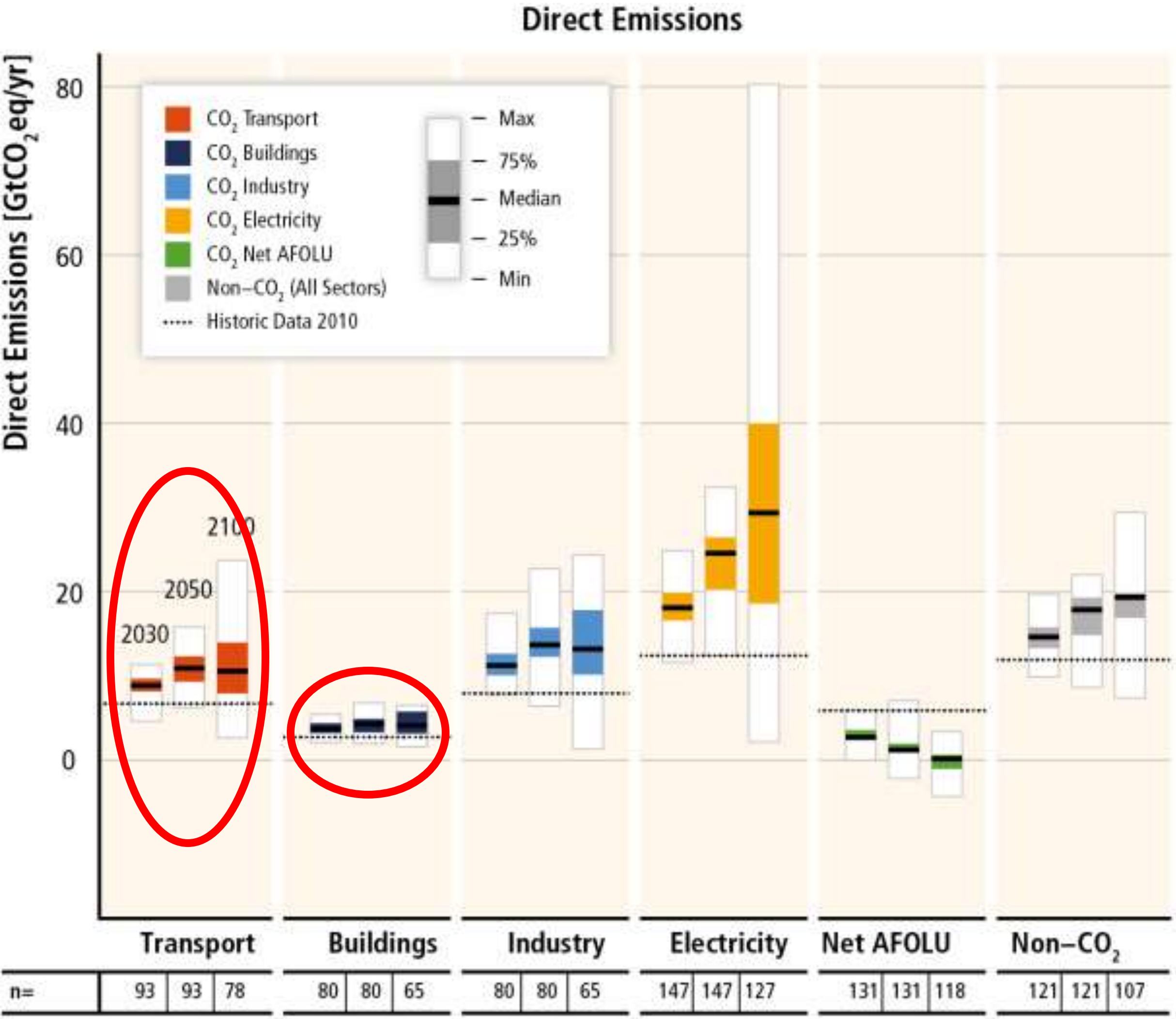
Systemic approaches to mitigation across the economy are expected to be most environmentally as well as cost effective.



Accounting for indirect emissions has key implications on mitigation strategy!

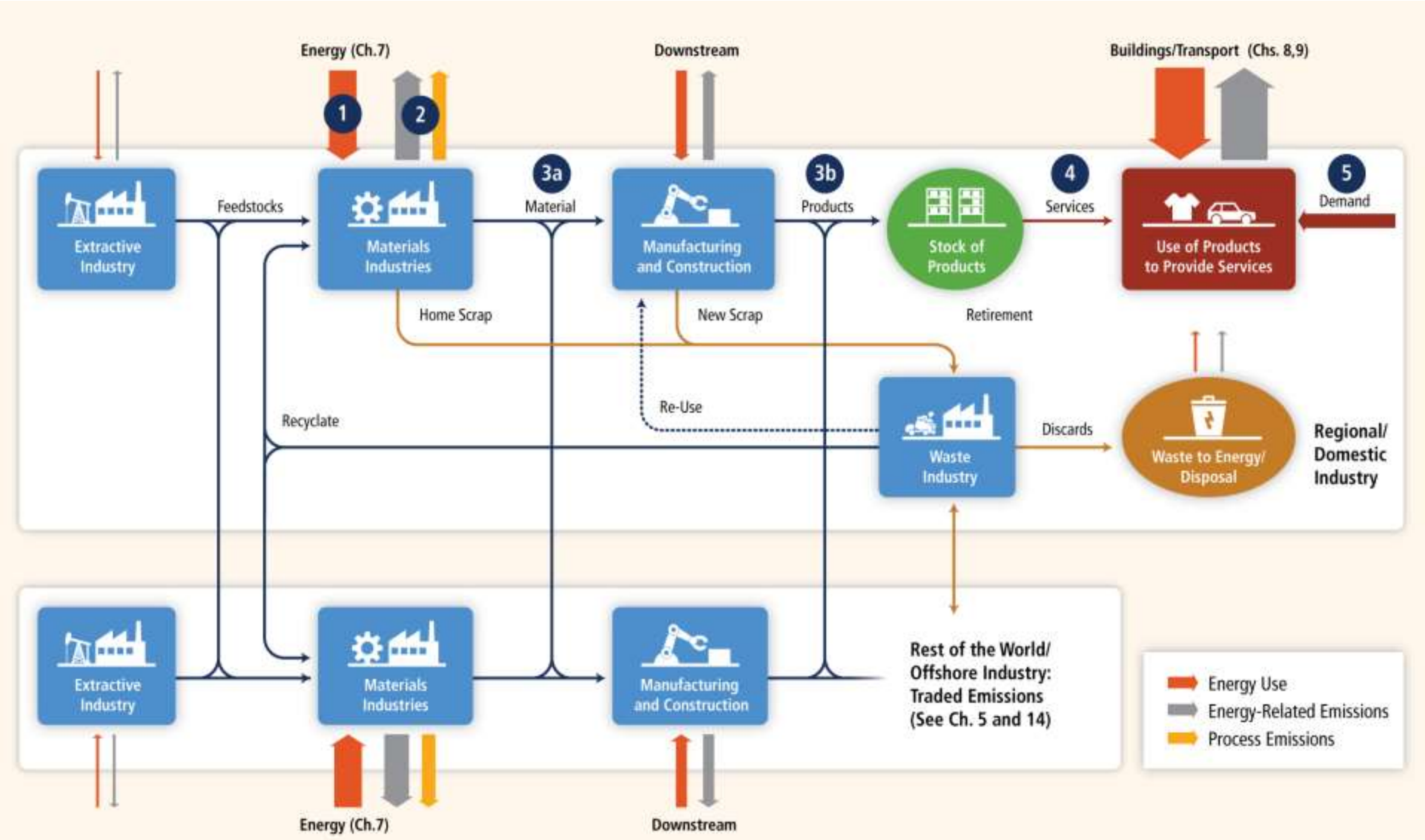


Baseline Scenarios: Direct vs. Indirect Emission Accounting



Source: Figure SPM.10, TS.15

Five main options for reducing GHG emissions related to industry (considering also traded goods)

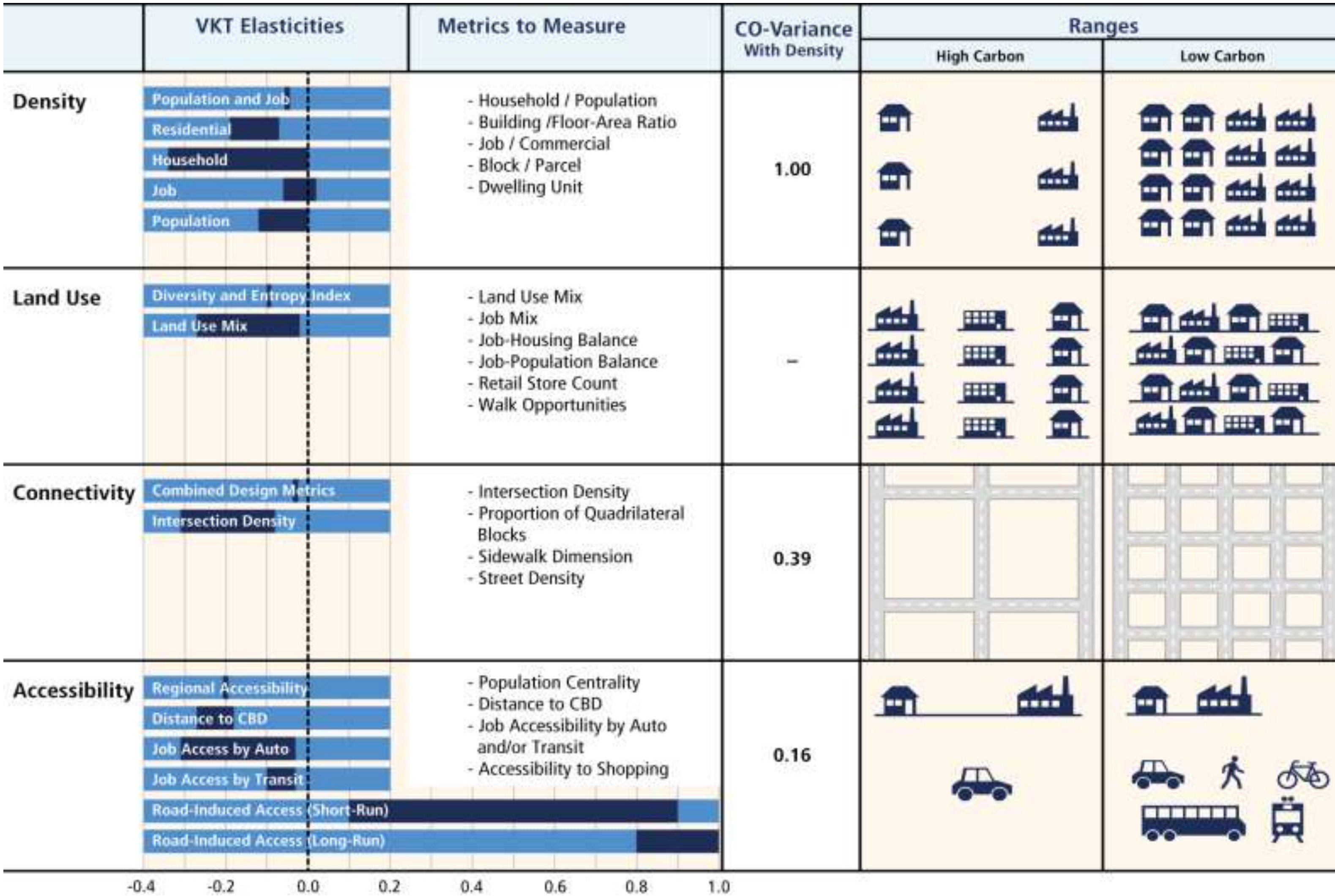


Industry

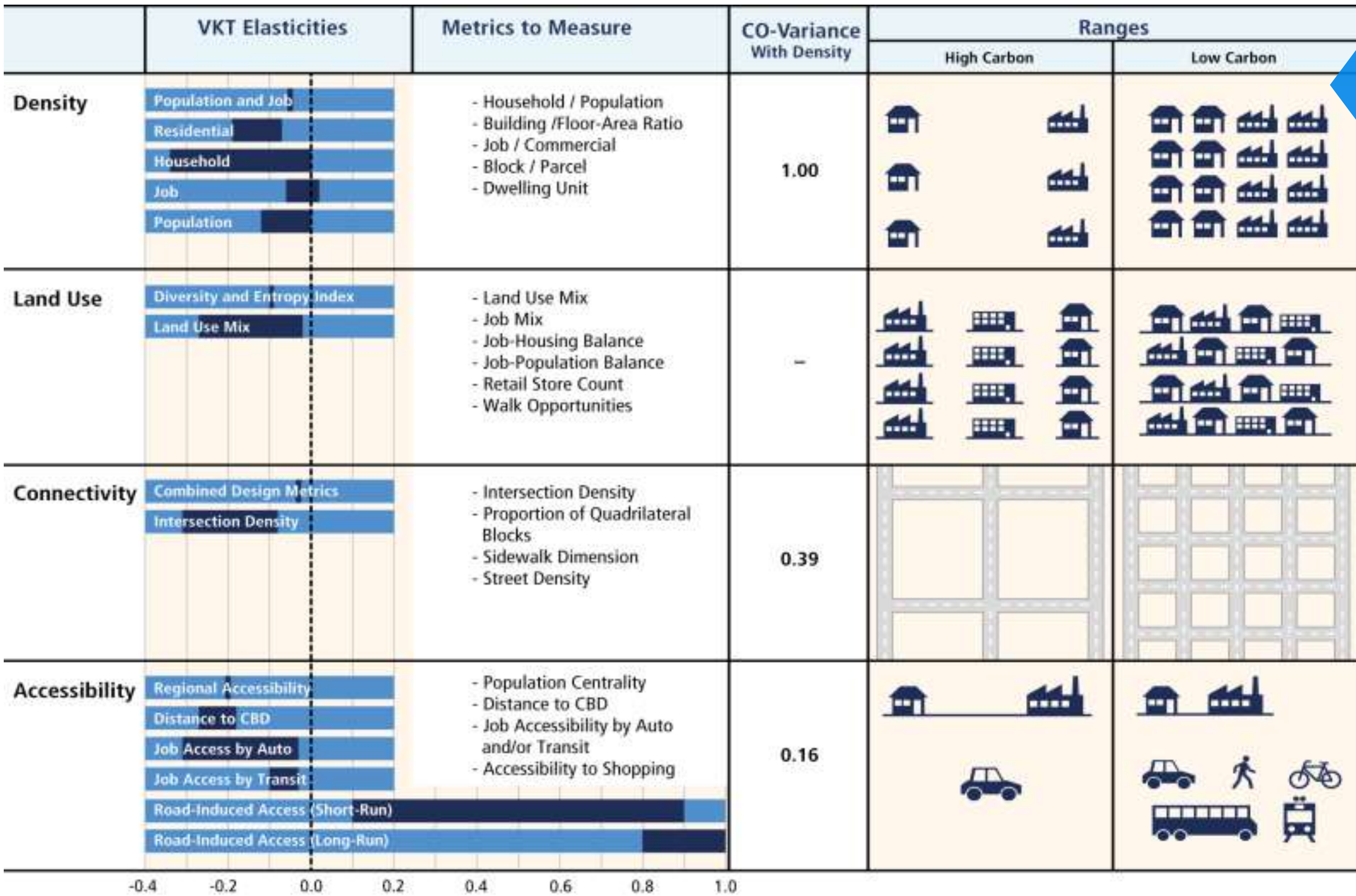
- In the long-term a shift to low-carbon electricity, radical product innovations (e.g. alternatives to cement), or CCS (for mitigating i.a. process emissions) could contribute to significant (absolute) GHG emissions reductions
- Systemic approaches and collaborative activities across companies and sectors and especially SMEs through clusters can reduce energy and material consumption and thus GHG emissions
- Important options for mitigation in waste management is waste reduction, followed by re-use, recycling and energy recovery

Mitigation through urban design

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

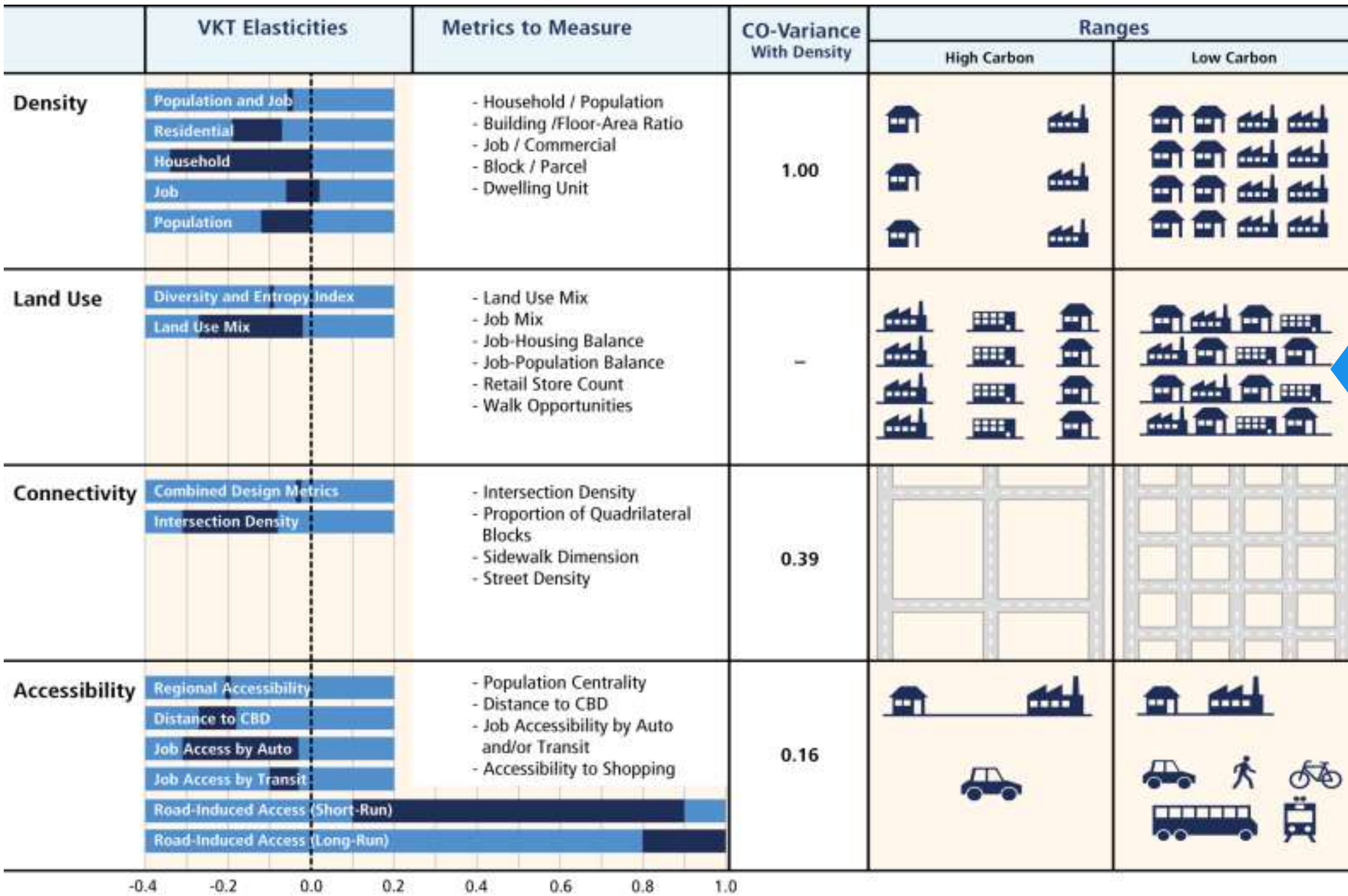


Increasing and co-locating residential and employment densities can lower emissions



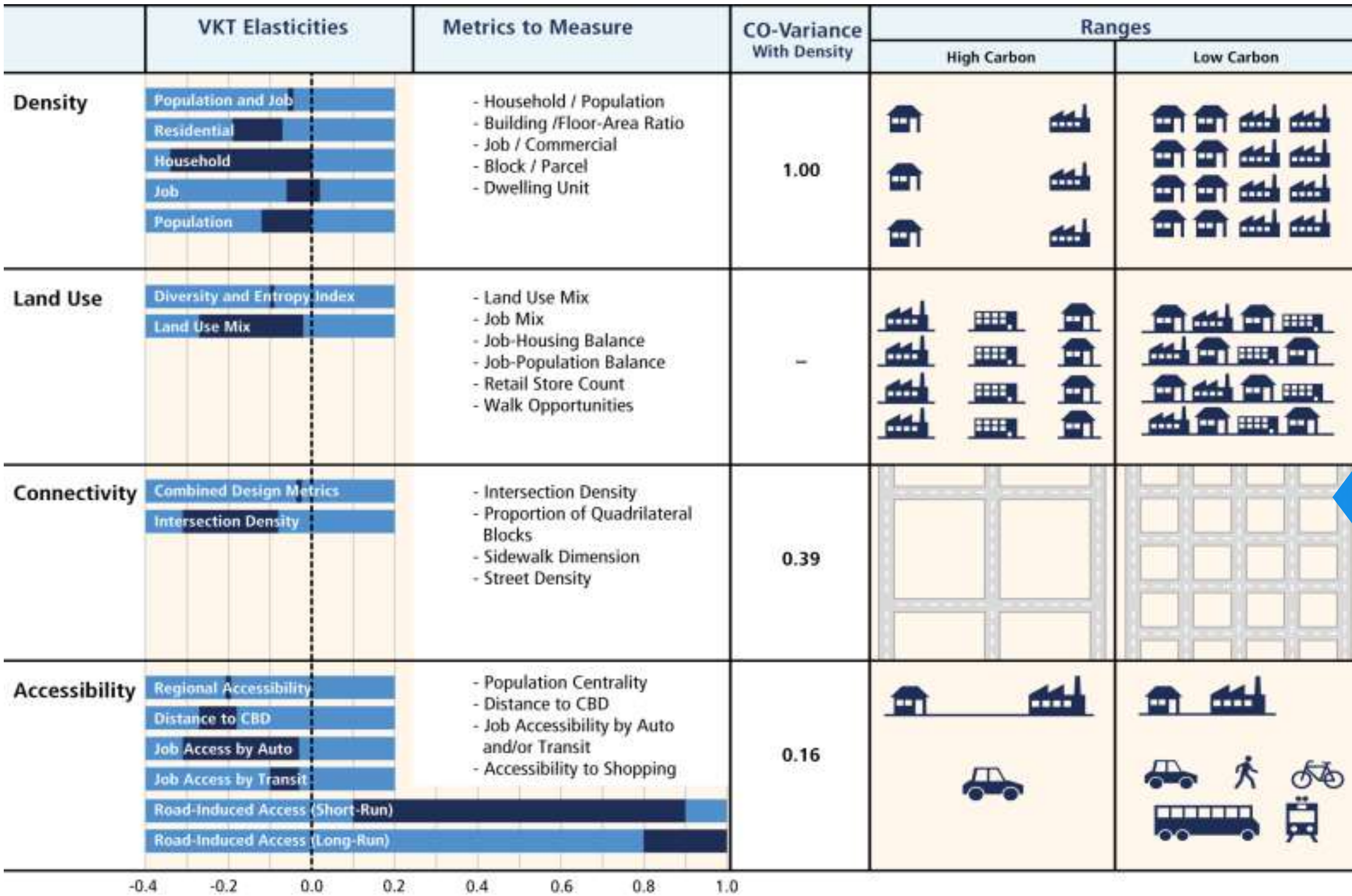
Higher density leads to less emissions (i.a. shorter distances travelled).

Increasing land use mix can significantly reduce emissions



Mix of land-use reduces emissions.

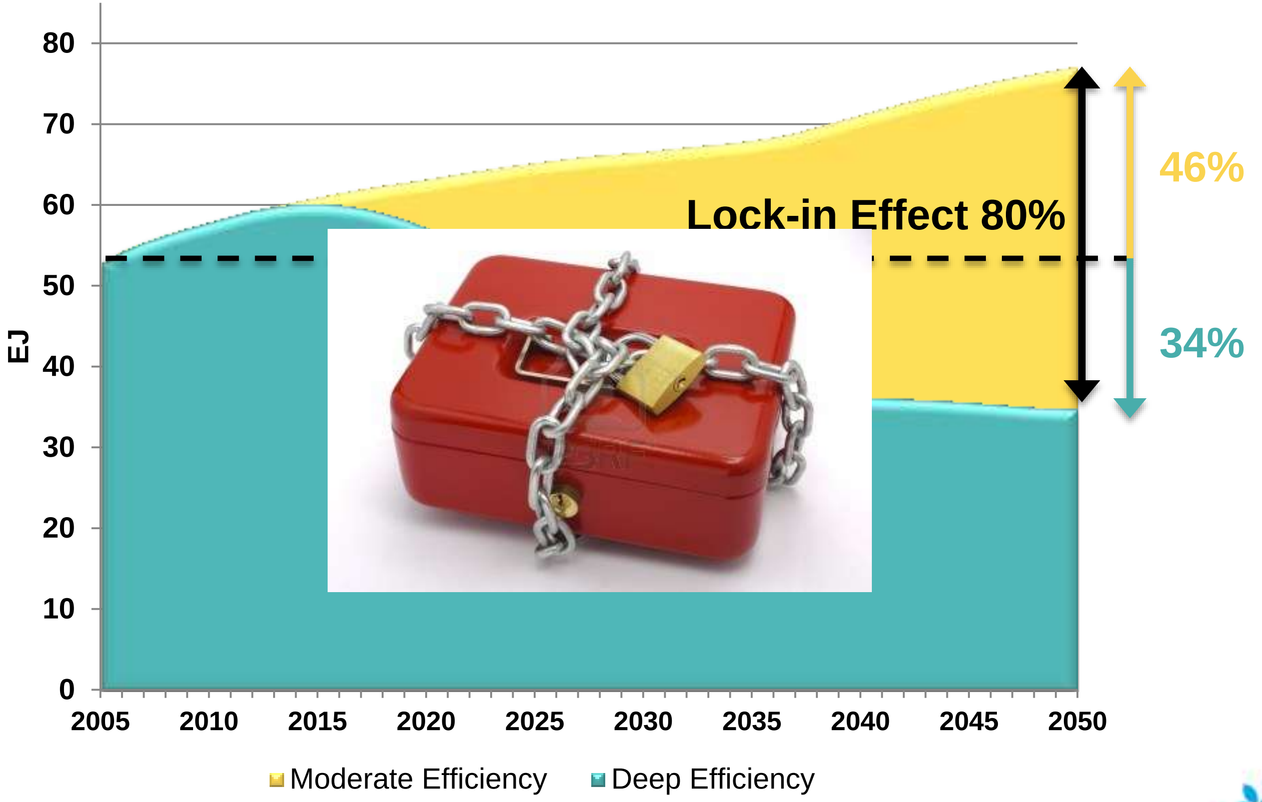
Increasing connectivity can enable multiple modes of transport



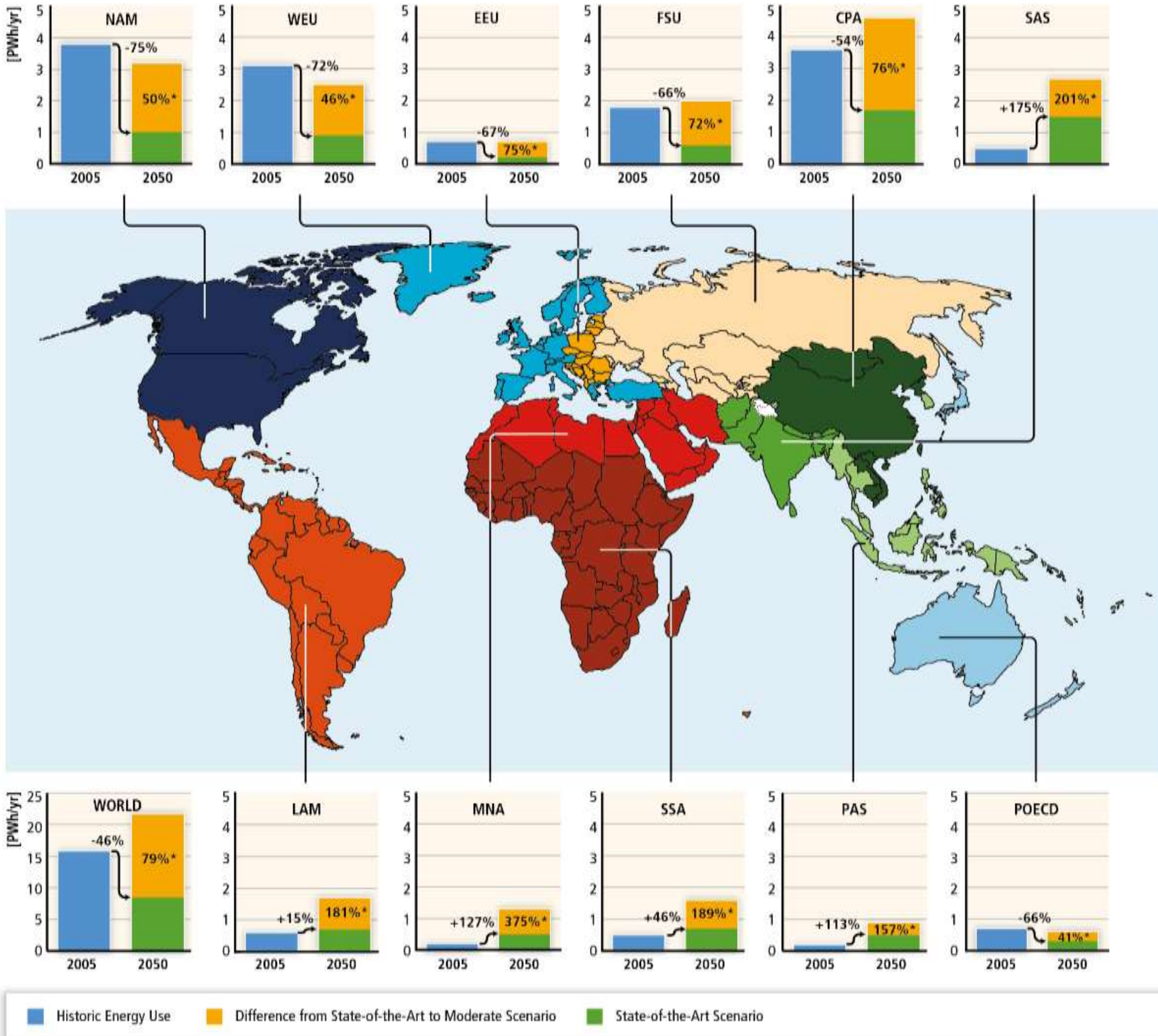
Improved infrastructural density and design (e.g. streets) reduces emissions.

However, there is a major lock-in risk

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



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.

Working Group III contribution to AR5: Mitigation

1 Summary for Policymakers

1 Technical Summary

16 Chapters

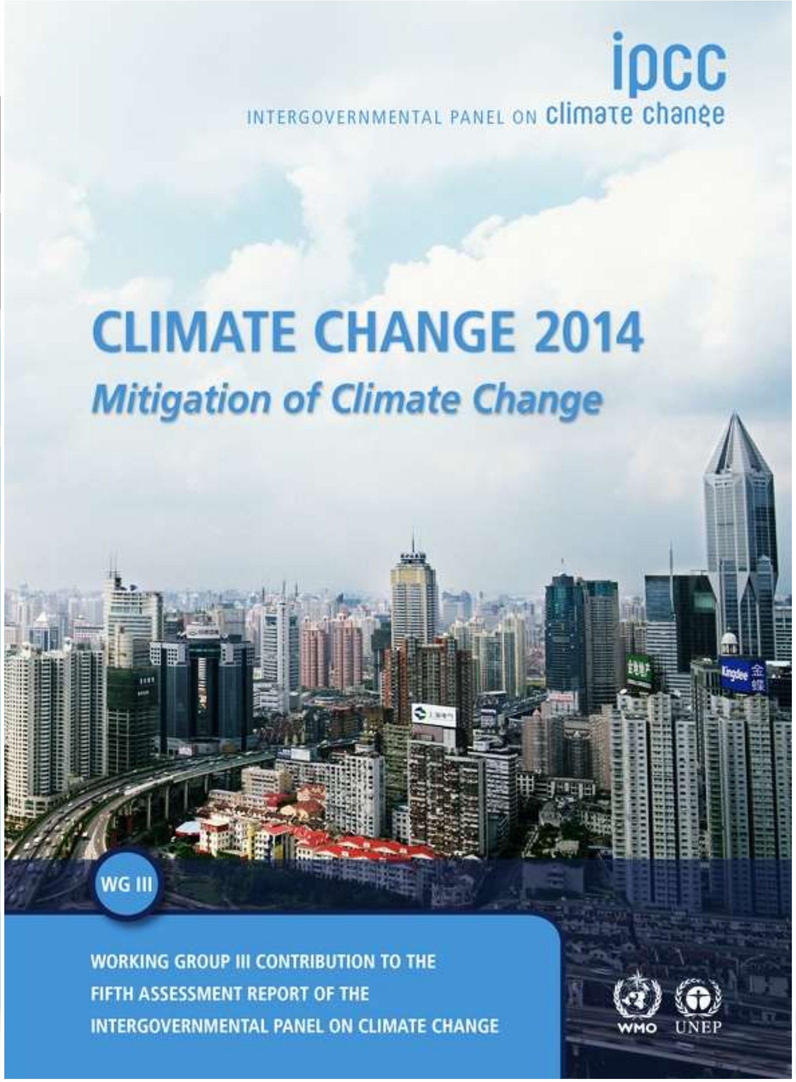
235 Authors

900 Reviewers

More than 2000 pages

Close to 10,000 references

More than 38,000 comments



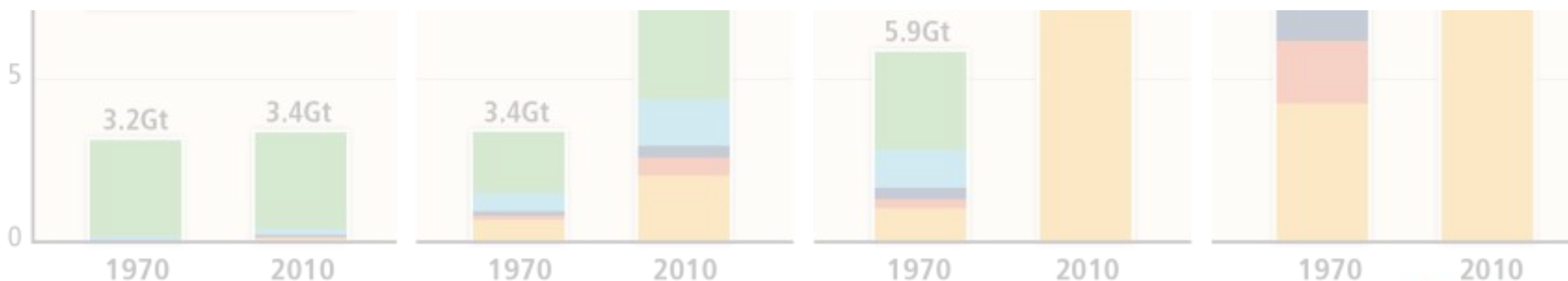
Working Group III contribution to the
IPCC Fifth Assessment Report

3CSEP

Regional patterns of GHG emissions are shifting along with changes in the world economy.

The following IPCC country delegations expressed their reservations to the WGIII report regarding income-based country groupings: Bahamas, Bolivia, Egypt, India, Iraq, Jordan, Malaysia, Maldives, Qatar, Saudi Arabia, Sudan, Syria, and Venezuela.

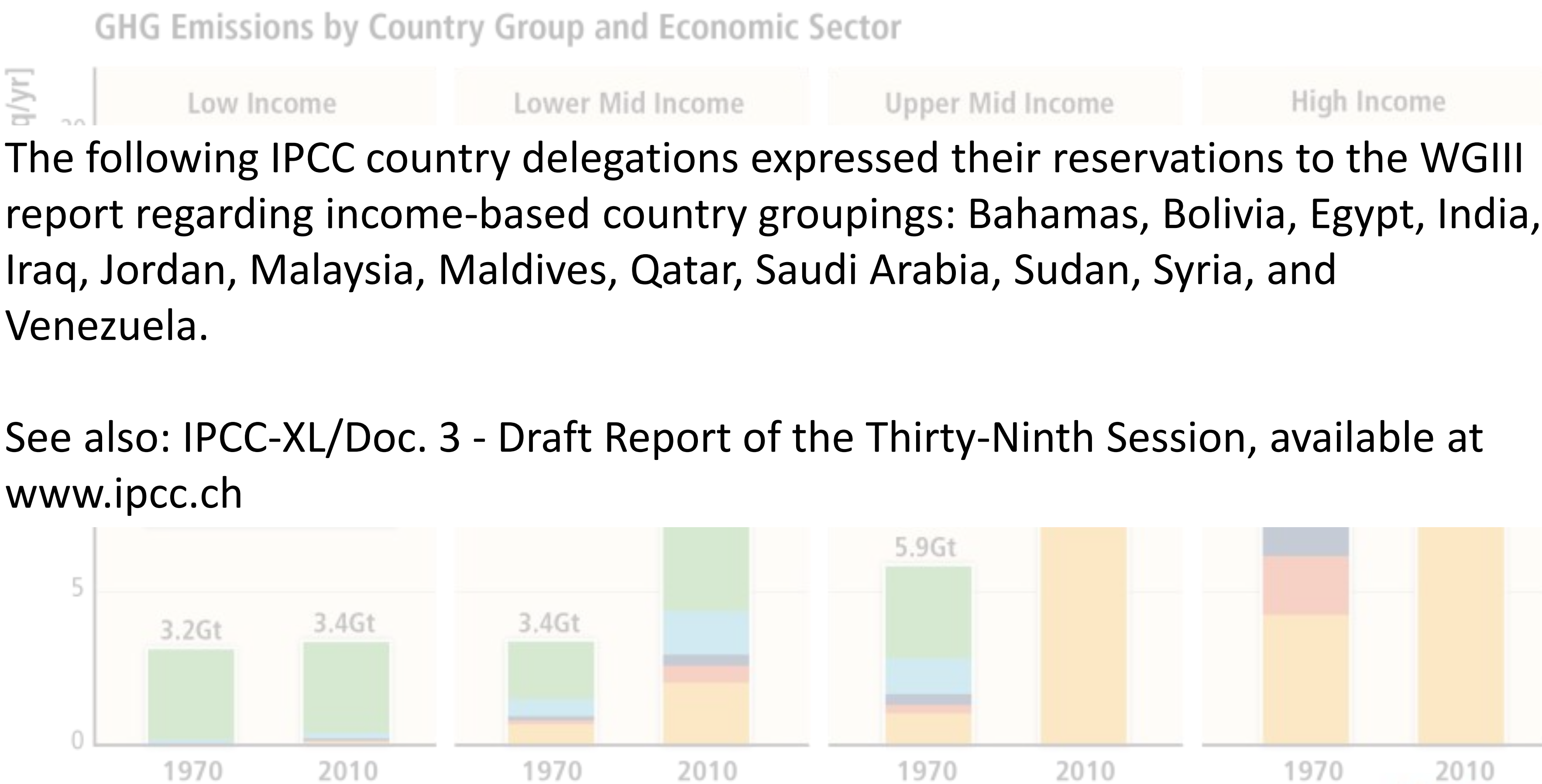
See also: IPCC-XL/Doc. 3 - Draft Report of the Thirty-Ninth Session, available at www.ipcc.ch



Based on Figure 1.6

3CSEP

Regional patterns of GHG emissions are shifting along with changes in the world economy.



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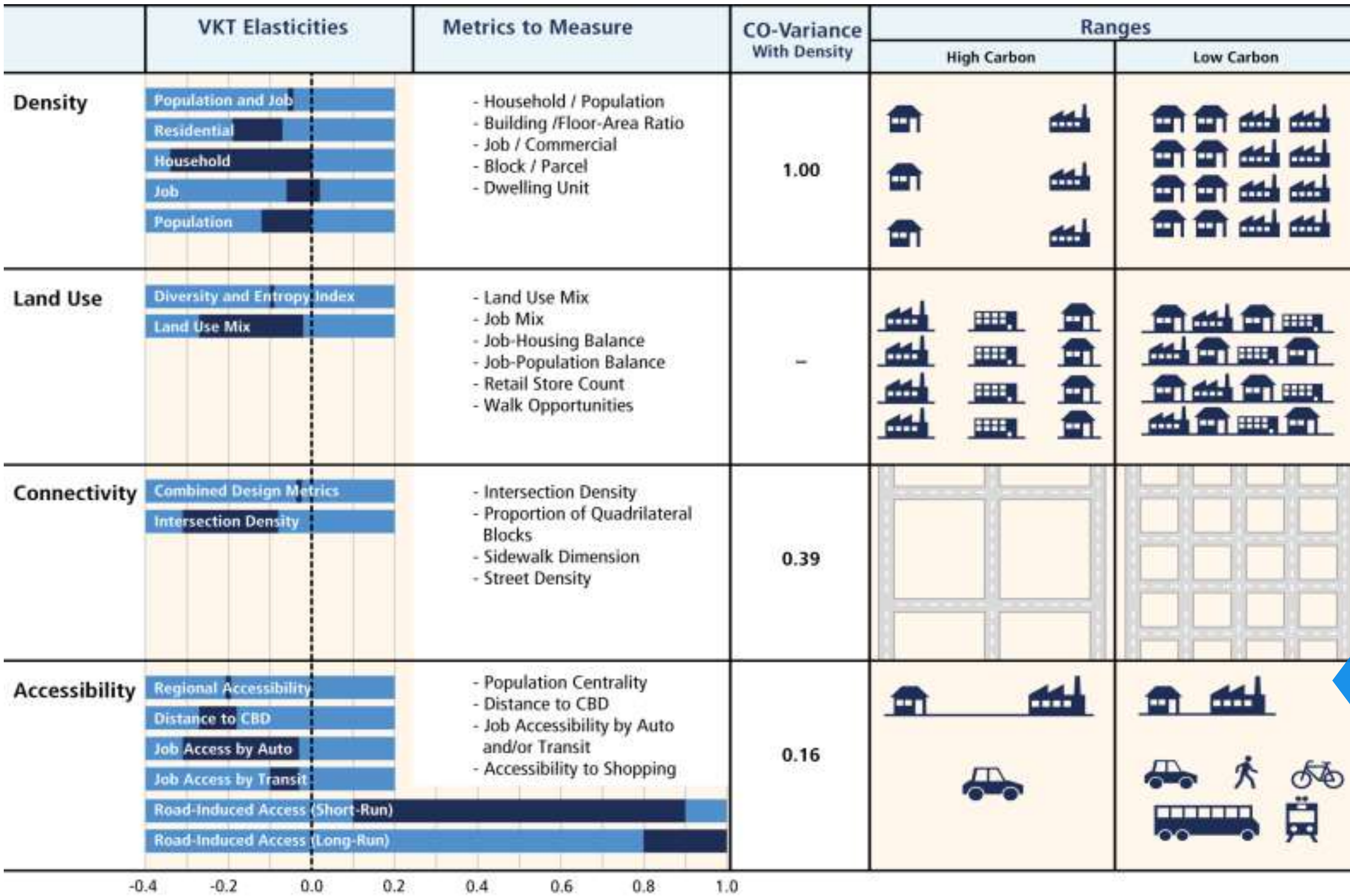
See also: IPCC-XL/Doc. 3 - Draft Report of the Thirty-Ninth Session, available at www.ipcc.ch

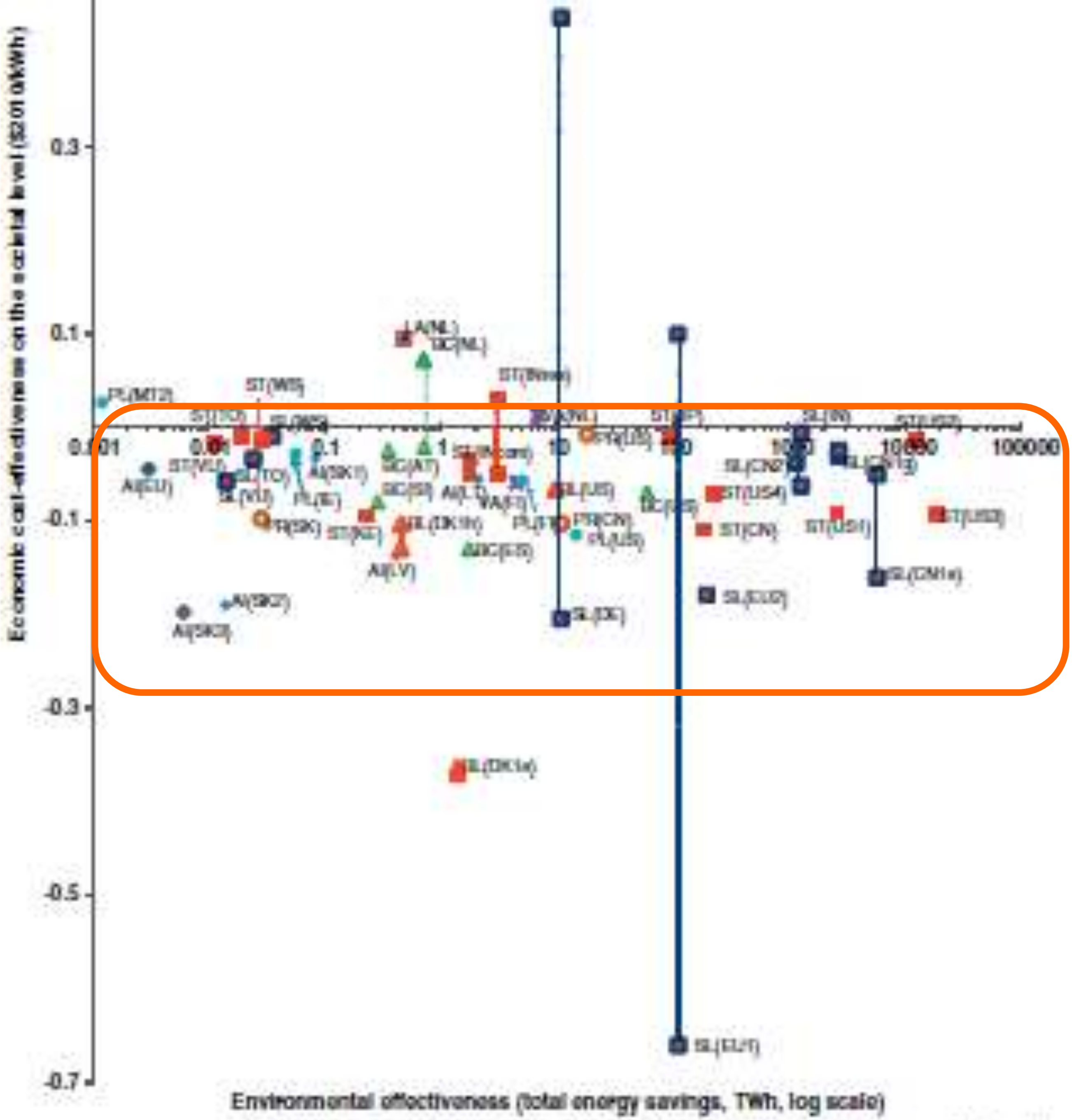
Based on Figure 1.6

Co-location of activities reduces direct and indirect GHG emissions



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

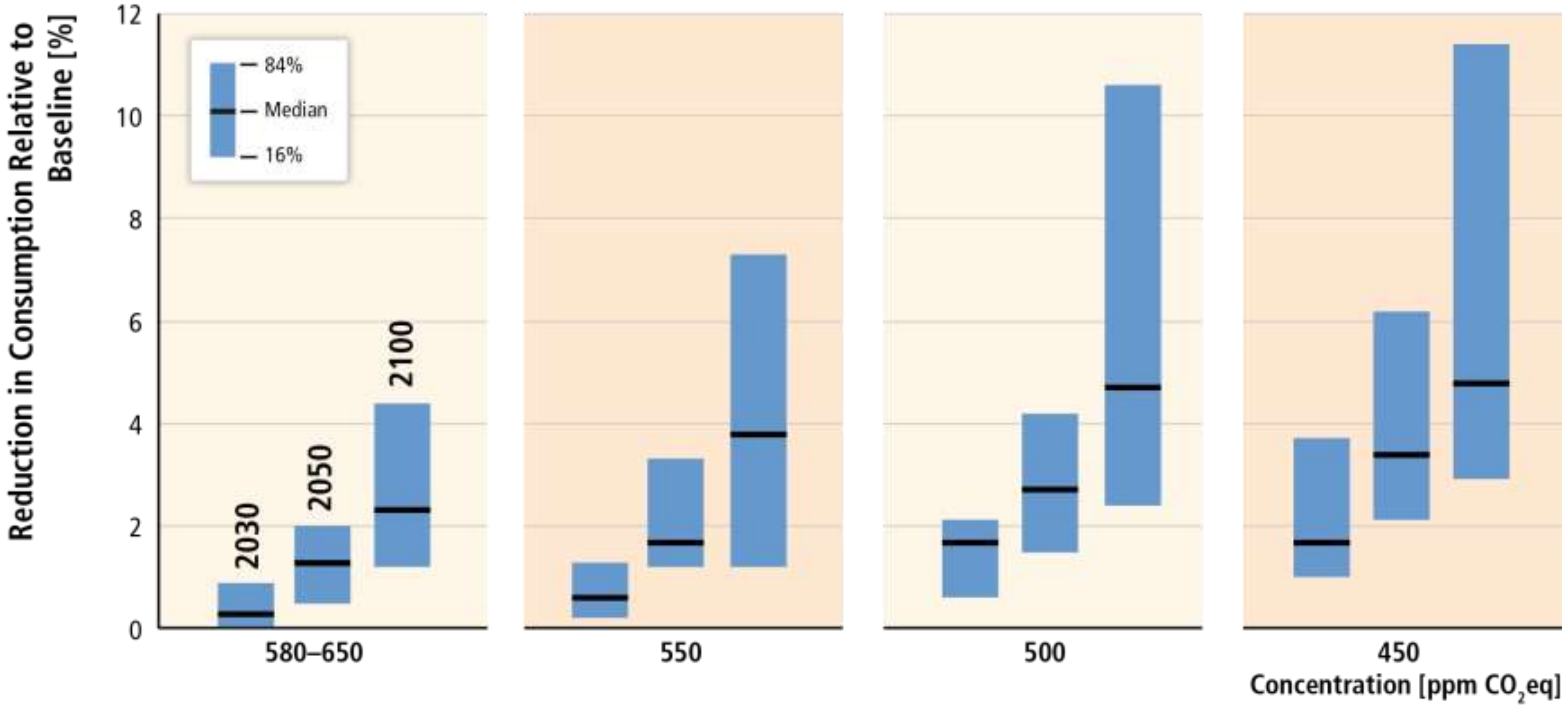
Cost of conserved carbon for implemented energy efficiency programs, post-ante evaluation results (based on data in Table 9.9 (boza-kiss et.al 2013 in COSUst)



Current Opinion in Environmental Sustainability

WMO UNEP

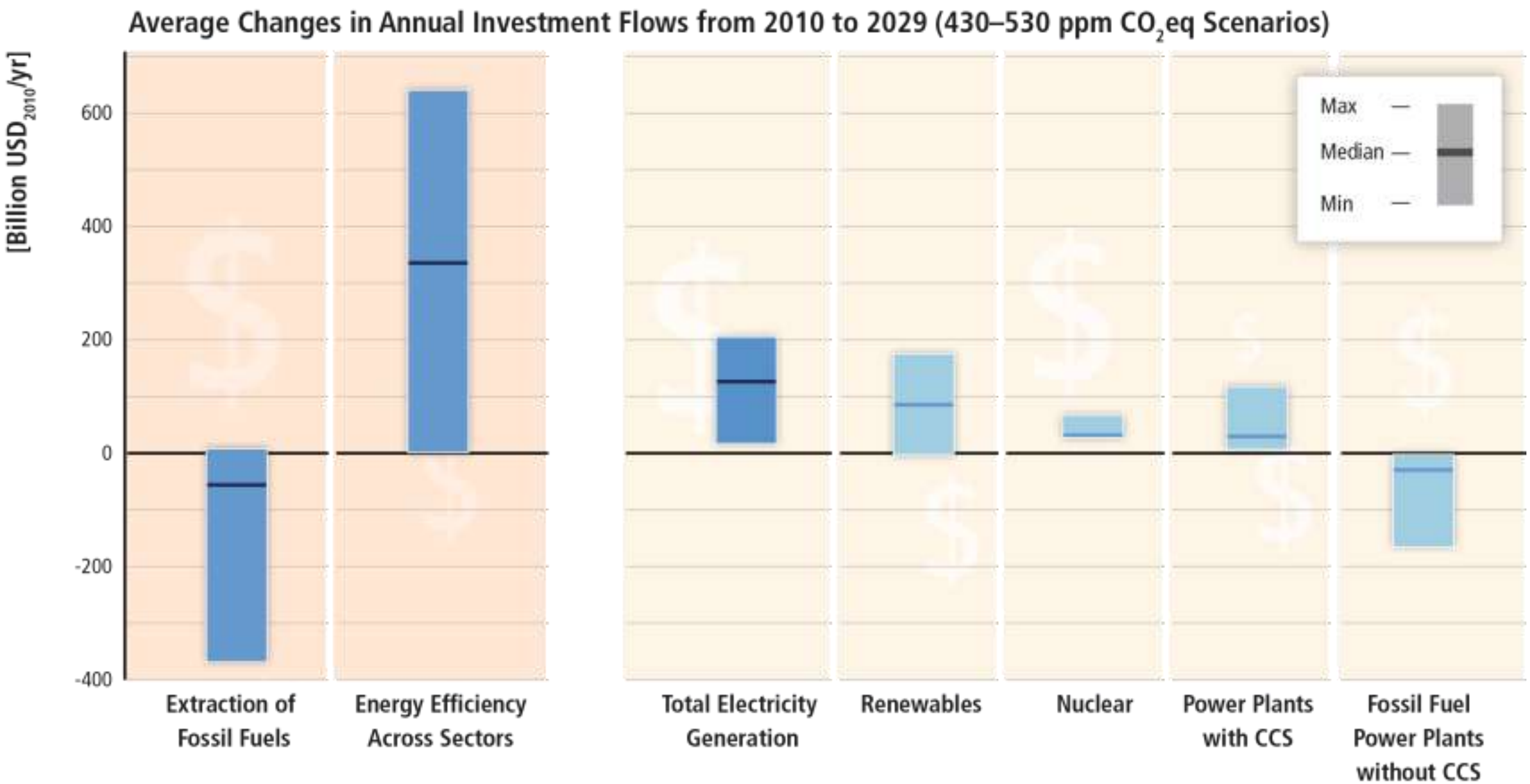
Global costs rise with the ambition of the mitigation goal.



Percentage Point Reduction in Annualized Consumption Growth Rate over 21st Century			
0.03 (0.01-0.05)	0.04 (0.01-0.09)	0.06 (0.03-0.13)	0.06 (0.04-0.14)

Based on Table SPM.2

Substantial reductions in emissions would require large changes in investment patterns and appropriate policies.



Based on Figure 16.3