GLOBAL COVENANT of MAYORS for CLIMATE & ENERGY

SEI Stockholm Environment Institute

COALITION FOR URBAN TRANSITIONS

ZERO CARBON CITIES BY 2050

MITIGATION POTENTIAL BY SECTOR AND LEVEL OF GOVERNMENT IN SIX KEY COUNTRIES

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INTRODUCTION

This short note summarises the results of a detailed study undertaken by the Stockholm Environment Institute for the Coalition for Urban Transitions, in partnership with the Global Covenant of Mayors. It provides an understanding of urban GHG abatement potential and the powers to deliver this by different tiers of government for six key countries: Brazil, China, India, Indonesia, Mexico, South Africa. Each of these countries are substantial players in their own right, so the decisions made within their borders are critical for achieving global goals, including the Paris Agreement. They are also some of the largest players in regional (if not global) markets, influencing and setting precedents for neighbouring countries.

The results of this study can inform the development of national low-carbon urban development strategies, including national enabling frameworks for city action in the countries covered. They can also be used by proactive cities and countries moving forward with ambitious climate policies, helping pinpoint where action is most needed as well as where experimentation might best contribute to national efforts. The cross-pollination of such efforts, both vertically and horizontally, will be essential for fully realizing the goals of the Paris Agreement.

More particularly, the powers analysis outlined for each of these countries sets out the level of government (national, local or shared) that has primary authority or influence over the modelled abatement potential. It is important to note that only a few expert interviews were conducted to produce this analysis. Results should be therefore considered as illustrative.

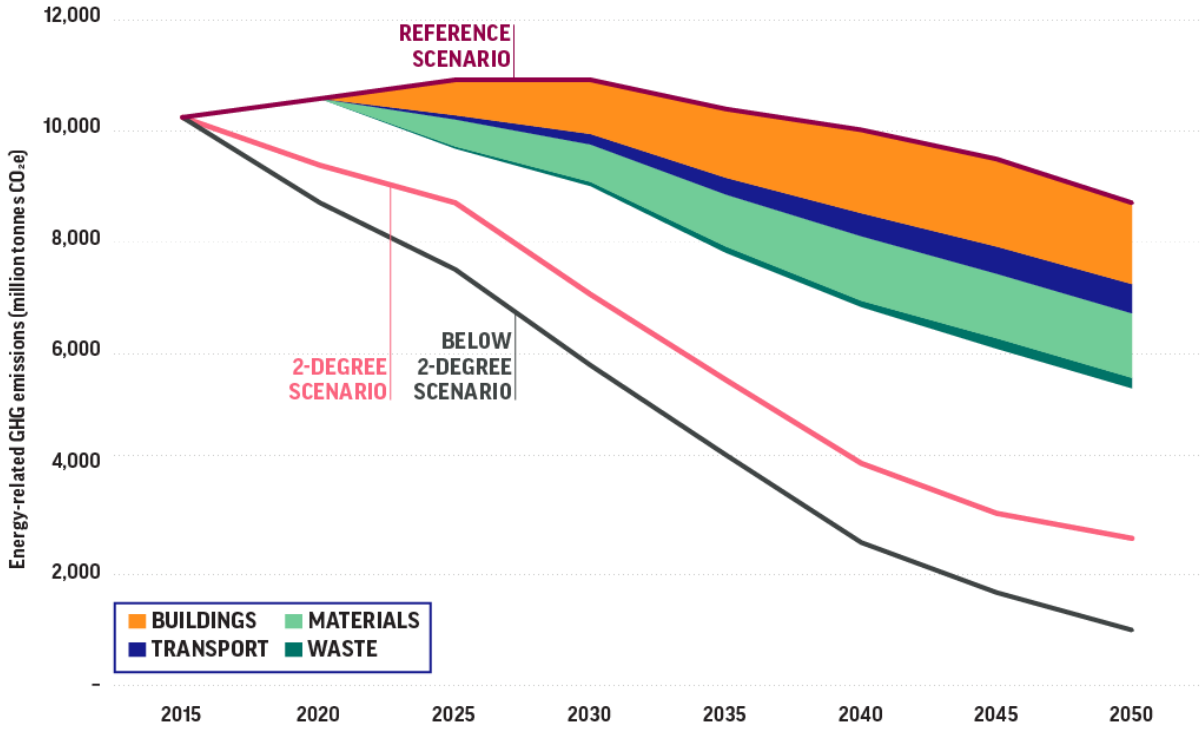
See Annex 1 for a list of the 25 abatement levers modelled across 4 main sectors: buildings, transport, materials, and waste. It is important to note that abatement potential is distinguished between total abatement potential and abatement potential excluding decarbonisation of the grid. Since higher levels of government generally hold the reins with respect to decarbonising the grid, when electricity decarbonisation is excluded from the analysis, the importance of local action and multi-level governance becomes more apparent. Annex 2 provides the results in terms of number of levers.

Full report available online:
urbantransitions.global/urban-opportunity/seizing-the-urban-opportunity/

CHINA

Altogether, our model suggests that actions to address GHG emissions from urban buildings, transportation, infrastructure construction, and waste could contribute about 40% of the total mitigation in energy-related emissions needed between 2020 and 2050 in China for a “below 2°C” scenario, as defined by the IEA (Figure 1). This is equivalent to over 50% of the mitigation needed for the IEA’s 2°C scenario for China.

Figure 1. Potential contribution of urban GHG abatement in China to Paris goals



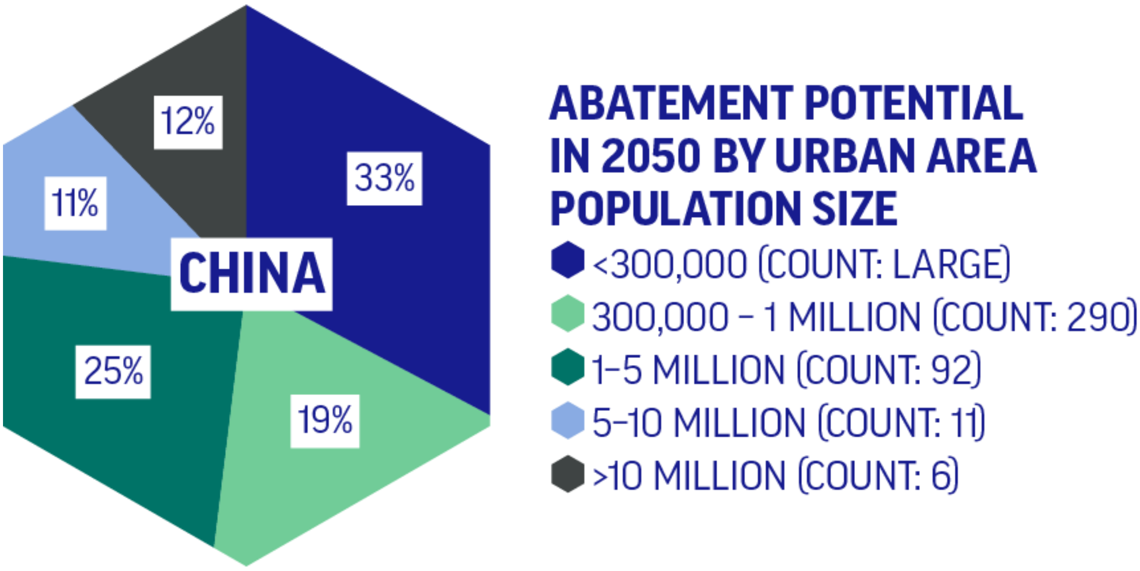
While China’s urban transportation sector offers considerable potential for GHG reductions, our model suggests that the largest abatement opportunities can be found in the buildings sector (Table 1). Given the expected need for new urban infrastructure (buildings and transportation), another important opportunity will be more efficient use of materials along with less GHG-intensive production methods.

Table 1. Cumulative modelled abatement potential by sector for China, 2020-2050

Sector	$MtCO_2e$	% of total
Buildings	34,124	48%
Materials	25,897	36%
Transport	8,915	12%
Waste	2,884	4%
TOTAL	71,821	100%

In China, our model suggests there is significant abatement potential in larger urban areas. About one eighth of the modelled GHG abatement potential in 2050 could be realized in China's six largest urban agglomerations: Shanghai, Beijing, Chongqing, Tianjin, Guangzhou, Guangdong, and Shenzhen. Close to one quarter of the potential could be achieved in urban areas with more than 5 million inhabitants, and nearly half could be realized in cities of over 1 million. However, this still leaves more than half of abatement potential in a large number of smaller urban areas.

Figure 2. China GHG abatement potential in 2050 by urban area population size



Major Chinese cities have been instrumental in piloting efforts related to building energy efficiency, urban design, and decarbonizing transportation and our analysis suggests these efforts should be deepened and expanded. Fully realizing the abatement potential in China's urban areas will mean replicating these efforts in smaller cities, which will require active support and enabling policies at the national levels.

Table 2. Proportion of 2050 urban abatement potential over which different levels of government have primary authority or influence

All abatement potential	Mt CO2e	% of total
Primarily local government	-	0%
Shared responsibility	10,100	14%
Primarily national/state governments	61,721	86%

All abatement except decarbonization of electricity	Mt CO2e	% of total
Primarily local government	-	0%
Shared responsibility	10,100	19%
Primarily national/state governments	41,957	81%

This means that national government have primary authority over 80% of total abatement potential whether or not decarbonization of electricity is considered.

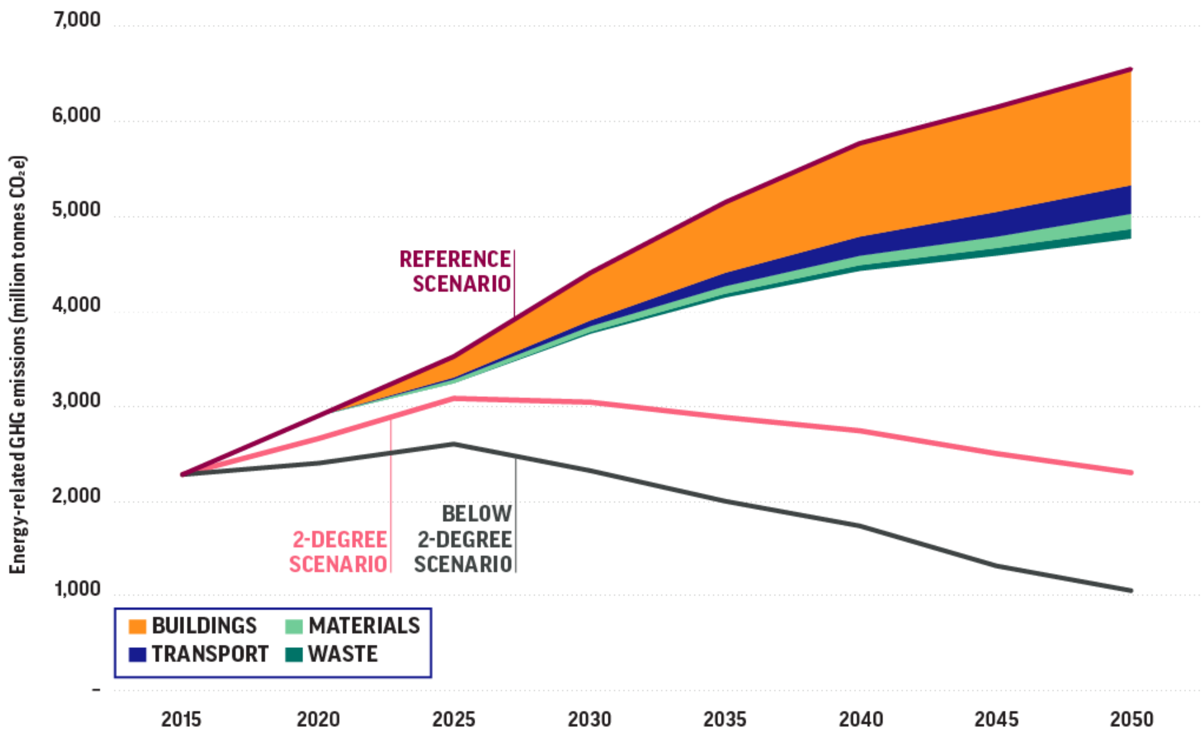
Policy priorities

- **Continued efforts to decarbonize the electricity sector.** This will require continued deployment of centralized renewable energy projects, but should also include collaboration between national, subnational, and local governments to expand adoption of distributed energy resources, including rooftop PV (Ohshita et al. 2015).
- **Aggressive electrification and efficiency improvements in residential and commercial buildings.** Buildings are a major source of potential GHG abatement in China. Improving building thermal integrity and electrifying or "solarizing" energy end uses – including space heating, water heating, and cooking – should continue to be major priorities. Improving building design and reducing the quantity of materials used in construction could also contribute significant GHG reductions. Local governments have significant roles to play here, so national and provincial policies should include efforts to improve coordination and enable effective standard-setting and enforcement across all city sizes.
- **Lowering the energy and emissions intensity of steel, cement, and aluminum production.** Our modeling suggests a large source of urban abatement potential in China is associated with lowering the emissions intensity of production for materials used in urban infrastructure. This is a major national-level opportunity, but local governments could be enlisted to set and enforce standards for materials GHG intensity in their procurement policies (primarily cement and steel).
- **Improving the efficiency of urban design.** Efforts to promote more compact, transit-oriented development could significantly reduce travel demand – especially for passenger vehicles – and reduce the amount of materials needed for new infrastructure construction. This will require measures at the subnational and local levels to move away from "superblock" development towards more efficient urban designs (Ohshita et al. 2015).

INDIA

Altogether, our model suggests that actions to address GHG emissions from urban buildings, transportation, infrastructure construction, and waste could contribute up to 32% of the total mitigation in energy-related emissions needed between 2020 and 2050 in India for a “below 2°C” scenario, as defined by the IEA (Figure 3). This is equivalent to over 40% of the mitigation needed for the IEA’s 2°C scenario for India.

Figure 3. Potential contribution of urban GHG abatement in India to Paris goals



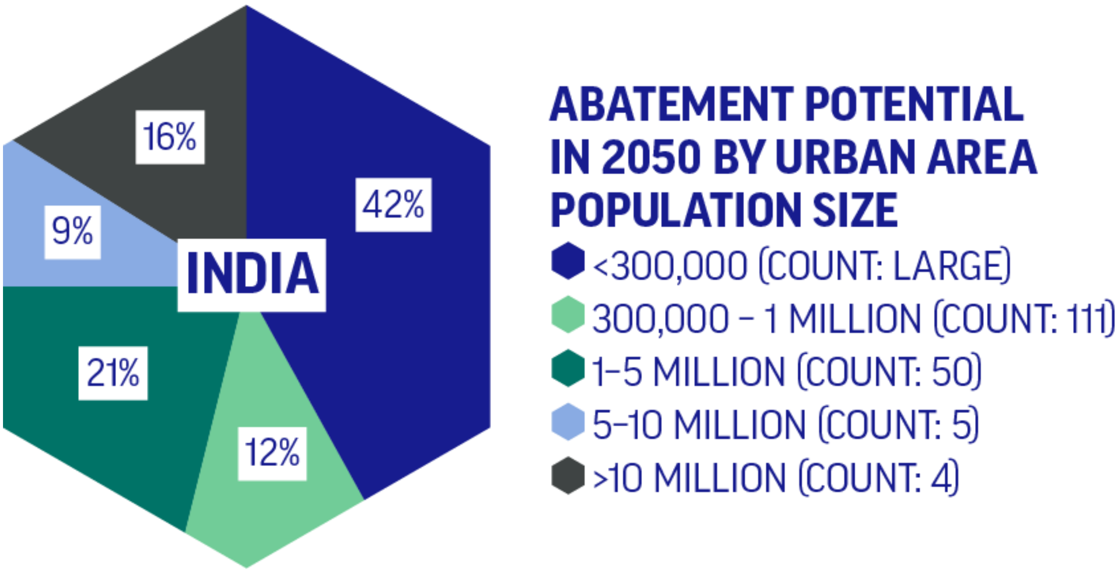
The greatest potential for *reducing* GHG emissions in Indian cities is in the buildings sector. In India, buildings account for around 70% of 2020 urban GHG emissions in our model (Table 3). This reflects the use of high-carbon fuels like coal and oil for building energy uses, along with the relatively high carbon intensity of India’s electricity grid.

Table 3. Cumulative modelled abatement potential by sector for India, 2020-2050

Sector	$MtCO_2e$	%
Buildings	21,371	72%
Transport	4,424	15%
Materials	2,351	8%
Waste	1,446	5%
TOTAL	29,591	100%

Fully one quarter of the modelled urban GHG abatement potential in 2050 could be realized in India's nine largest cities, i.e., the metropolitan areas of Delhi, Mumbai, Kolkata, Bangalore, Chennai, Hyderabad, Ahmadabad, Pune, and Surat. At the same time, over half the abatement potential would need to be achieved in urban areas with current populations of less than 1 million – including over 40% in smaller urban areas with fewer than 300,000 residents. This suggests the need for nationally coordinated policy efforts that will enable municipalities of all sizes to undertake abatement measures.

Figure 4. India GHG abatement potential in 2050 by urban area population size



The degree of variation in urban governing authority in India makes it difficult to generalize about where cities can (or should) take the lead on climate action, as opposed to the national or state governments. Given the large relative potential of the buildings sector to reduce or avoid emissions, cooperative approaches for improving building energy efficiency and decarbonizing the power sector will continue to be essential.

Table 4. Proportion of 2050 urban abatement potential over which different levels of government have primary authority or influence

All abatement potential	Mt CO2e	% of total
Primarily local government	1,244	4%
Shared responsibility	4,512	15%
Primarily national/state governments	23,836	81%

All abatement except decarbonization of electricity	Mt CO2e	% of total
Primarily local government	1,244	8%
Shared responsibility	4,512	30%
Primarily national/state governments	9,075	61%

This means that national government have primary authority over 80% of total abatement potential and 60% when decarbonisation of electricity is excluded.

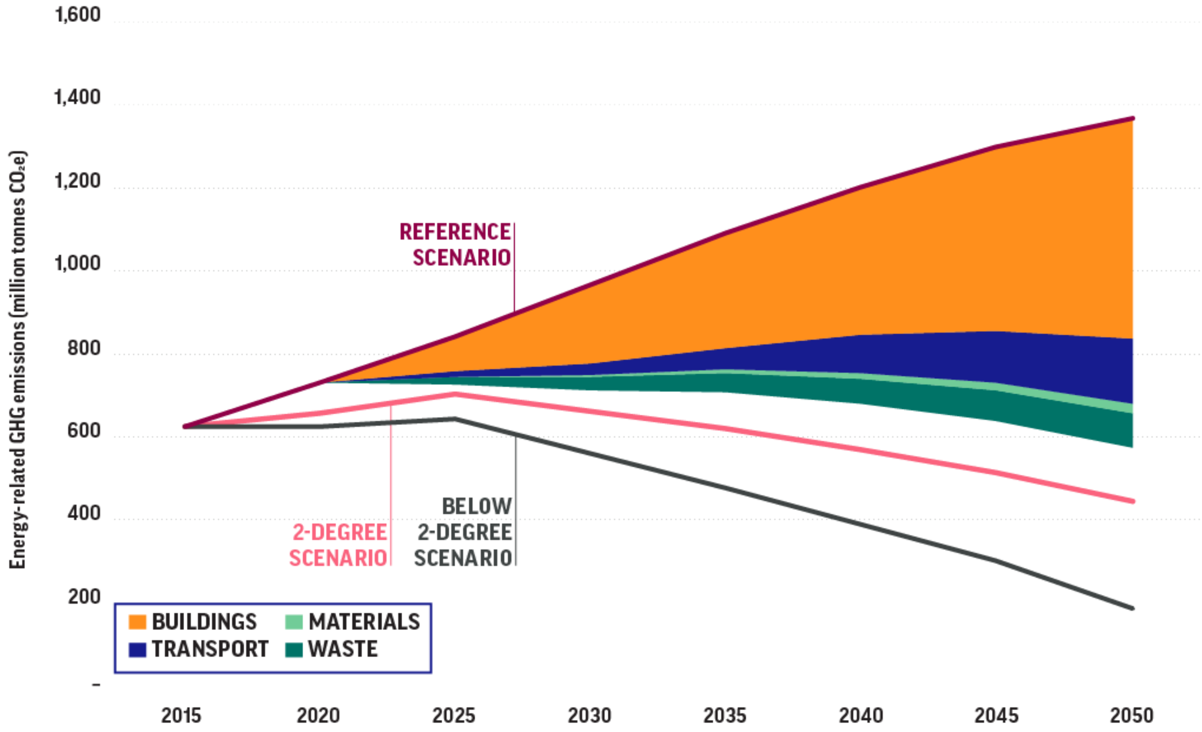
Policy priorities

- **Continued efforts to decarbonize the electricity sector**. Our analysis suggests the paramount importance of decarbonizing electricity in India for achieving GHG reductions in both the buildings and transportation sectors. Efforts should include collaboration between state and local governments to expand adoption of distributed solar, as well as centrally led efforts to upgrade India's transmission and distribution systems (Gillard et al. 2018).
- **Aggressive electrification and efficiency improvements in residential and commercial buildings**. Our analysis suggests that buildings are a major source of potential GHG abatement in India. Improving building thermal integrity and electrifying or "solarizing" energy end uses – including for space heating, water heating, and cooking – should continue to be major priorities.
- **Improving multi-level and metropolitan coordination related to housing, urban design, transportation, and waste management**. India's sometimes fragmented and complex governance arrangements in urban areas –especially related to housing, urban form, and waste management (Gillard et al. 2018; Oates et al. 2018) – could present significant challenges to fully realizing urban GHG abatement. Given the still-significant abatement potential associated with these sectors, especially in transport, overcoming these challenges could be a key priority.

INDONESIA

Altogether, our model suggests that actions to address GHG emissions from urban buildings, transportation, infrastructure construction, and waste could contribute over 65% of the total mitigation in energy-related emissions needed between 2020 and 2050 in Indonesia for a "below 2°C" scenario, as defined by the IEA (Figure 5). This is equivalent to 85% of the mitigation needed for the IEA's 2°C scenario for Indonesia.

*Figure 5. Potential contribution of urban GHG abatement in Indonesia to Paris goals**



The buildings sector in Indonesia, dominates both total GHG emissions and GHG abatement potential for the sectors modelled. In part, this reflects the relatively high carbon intensity of Indonesia's electricity grid. As Table 5 indicates, this corresponds to a large relative opportunity for emission reductions – nearly 70% of the cumulative abatement potential between 2020 and 2050 could come from buildings. A majority of the abatement potential in the buildings sectors is associated with decarbonizing electricity.

Table 5. Cumulative modelled abatement potential by sector for Indonesia, 2020-2050

Sector	$MtCO_2e$	% of total
Buildings	8,328	69%
Transport	2,017	17%
Materials	1,368	11%
Waste	304	3%
TOTAL	12,016	100%

The bulk of urban GHG abatement potential in Indonesia is spread across many smaller urban areas. Although nearly 25% of the abatement potential we model for 2050 could be achieved in 13 urban areas with 2015 populations over 1 million, fully two thirds are associated with urban areas with less than 300,000 population in 2015 (Figure 6). To realize this potential, Indonesia will need to adopt policies that address urban GHG emissions across a large number of smaller cities.

Figure 6. Indonesia GHG abatement potential in 2050 by urban area population size

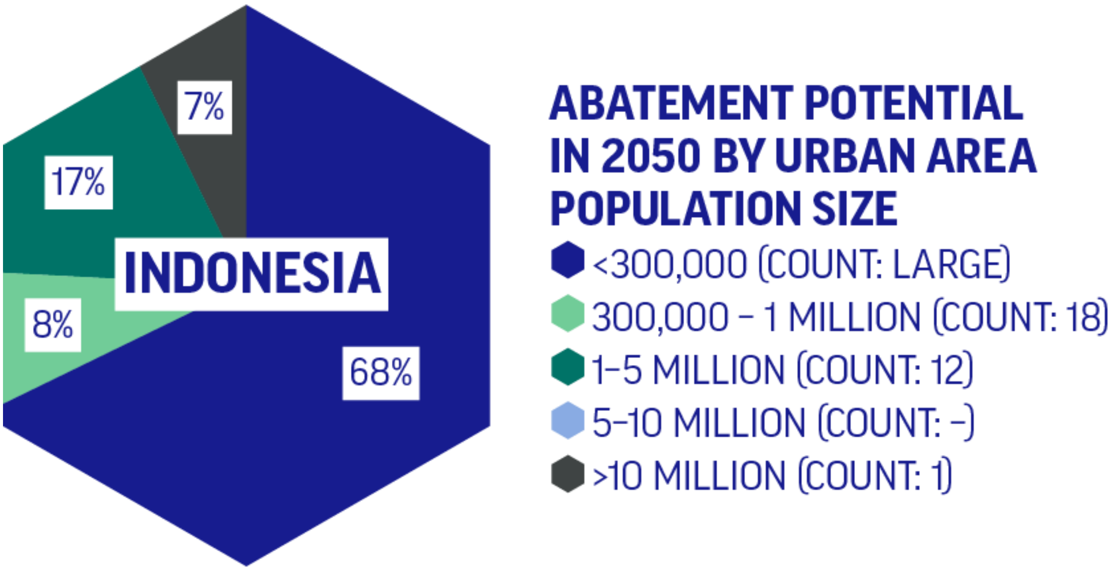


Table 6. Proportion of 2050 urban abatement potential over which different levels of government have primary authority or influence

All abatement potential	Mt CO2e	% of total
Primarily local government	865	7%
Shared responsibility	4,493	37%
Primarily national/state governments	6,659	55%

All abatement except decarbonization of electricity	Mt CO2e	% of total
Primarily local government	865	15%
Shared responsibility	4,493	78%
Primarily national/state governments	399	7%

This means that national government have primary authority over 55% of total abatement potential and 7% when decarbonisation of electricity is excluded. Shared responsibility is prevalent in Indonesia mainly because fiscal and administrative functions are highly decentralized, with local governments exercising authority in a number of policy areas important for GHG abatement.

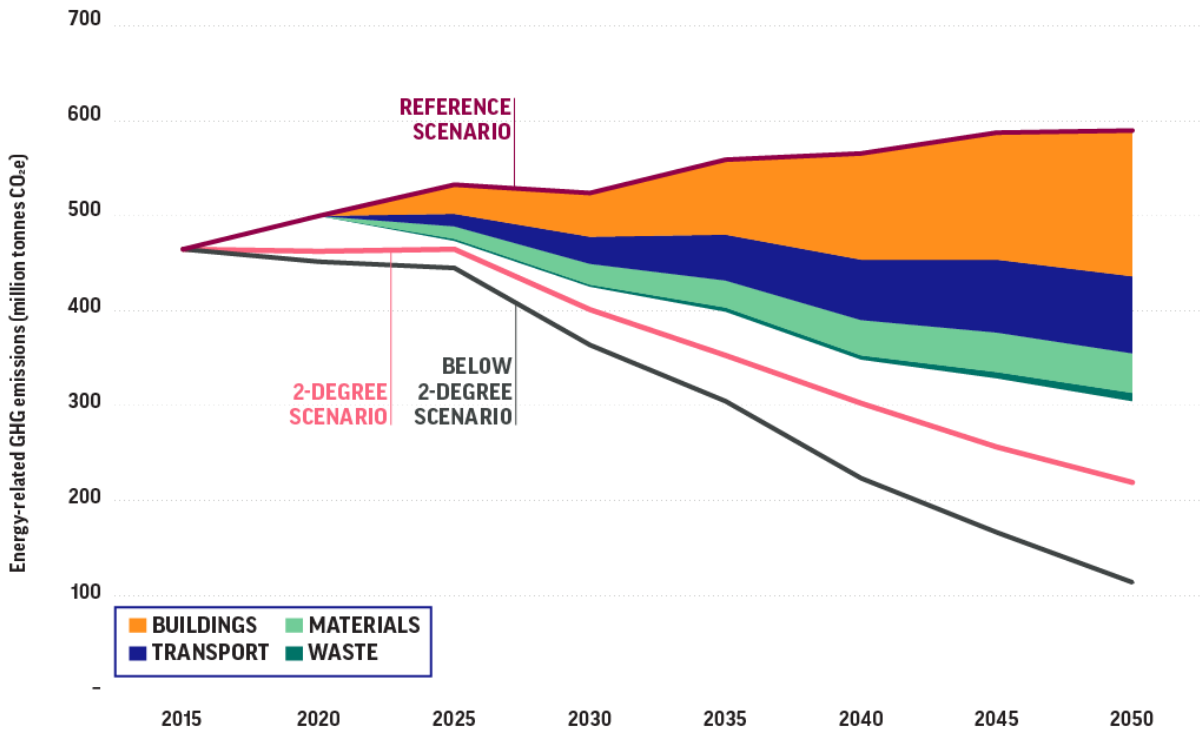
Policy priorities

- **Aggressive electrification and efficiency improvements in residential and commercial buildings**. Our analysis suggests building energy efficiency could be a major source of urban GHG abatement in Indonesia, especially as cities continue to grow. Studies suggest higher efficiency standards for appliances and lighting would be highly cost-effective, avoiding the need for substantial new electricity generation capacity (McNeil et al. 2019). The national government should continue to move forward with recently announced energy efficiency targets (Desk Editor Insider 2020). Efforts to improve building thermal integrity and electrify end uses – including for space heating, water heating, and cooking – should be key priorities. Local governments could be key partners in these efforts.
- **Decarbonize the electricity sector**. Our analysis suggests the critical importance of decarbonizing electricity in Indonesia for both the buildings and transportation sectors. Efforts should include collaboration between Indonesia's national utility (Perusahaan Listrik Negara) and local governments to expand adoption of distributed energy resources, including rooftop PV (Wijaya et al. 2020).
- **Promote compact, transit-oriented development and active transportation options in growing cities**. Our analysis suggests significant potential to avoid increasing emissions from urban population growth through a shift to more compact development and adoption of travel-demand management policies, along with expanded public transit, walking, and cycling options. Jakarta's efforts to improve transit network connections, promote transit-oriented development, and improve traffic management (including through development of Low Emission Zones) should be expanded and replicated in other cities (Environment Agency of DKI Jakarta and Vital Strategies 2020).

MEXICO

Altogether, our model suggests that actions to address GHG emissions from urban buildings, transportation, infrastructure construction, and waste could contribute nearly 60% of the total mitigation in energy-related emissions needed between 2020 and 2050 in Mexico for a “below 2°C” scenario, as defined by the IEA (Figure 7). This is equivalent to over 75% of the mitigation needed for the IEA’s 2°C scenario for Mexico.

Figure 7. Potential contribution of urban GHG abatement in Mexico to Paris goals



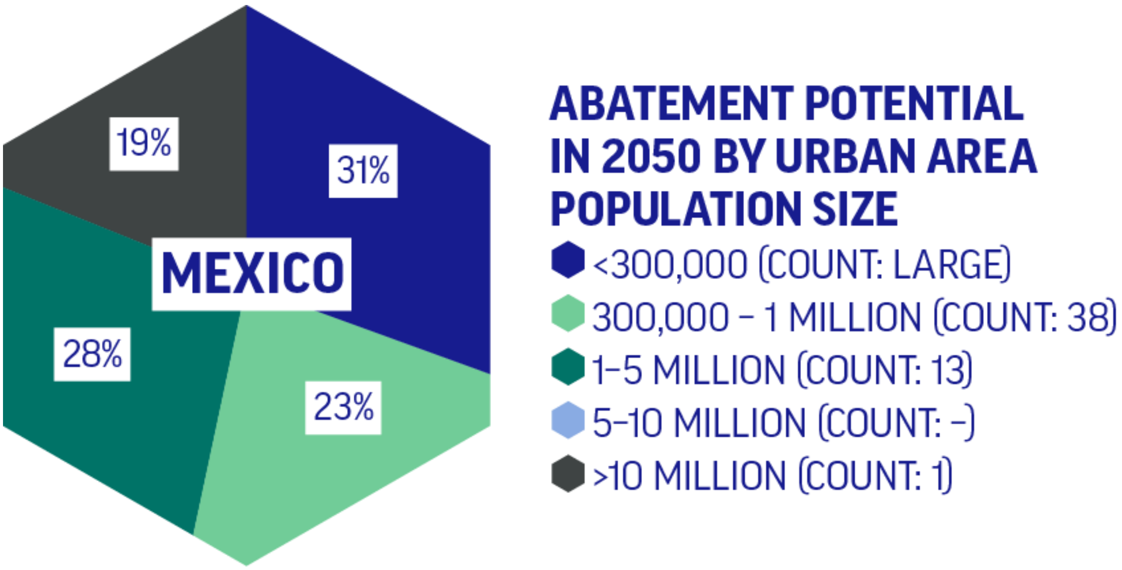
Our model suggests GHG emissions from urban buildings, transportation, waste, and infrastructure construction in Mexico will increase by over 20% between 2020 and 2050 under BAU (Figure 7). This increase is driven by increases in building sector emissions (a 45% increase) and emissions from infrastructure construction (around a 30% increase). Urban transportation emissions are projected to *decline* by around 5% by 2050, due largely to improvements in freight sector fuel economy. More so than in other countries, our model suggests that Mexico should pursue an “all of the above” approach to reducing urban GHG emissions.

Table 7. Cumulative modelled abatement potential by sector for Mexico, 2020-2050

Sector	$MtCO_2e$	% of total
Buildings	2,447	51%
Transport	1,397	29%
Materials	843	18%
Waste	113	2%
TOTAL	4,799	100%

As in other countries, urban GHG abatement potential in Mexico is distributed across cities of varying sizes. In Mexico, however, a relatively large percentage of the total potential is in larger urban areas. Fully 19% of GHG reductions in 2050 could be achieved in Mexico City alone (Figure 8). Another 50% could be achieved in about 50 other urban areas with populations over 300,000. This still leaves 30% of abatement potential in a large number of smaller urban areas, but compared to other countries we examined, Mexico can achieve more abatement by focusing on its larger urban areas. These large urban areas will need the support of national government through regulations, finance, and information to unlock their full potential.

Figure 8. Mexico GHG abatement potential in 2050 by urban area population size



While national laws set the agenda for urban climate action in Mexico, much of the authority and responsibility for enacting the agenda is delegated to state and municipal governments. Urban municipalities in particular bear a large share of responsibility for some key GHG abatement strategies, notably for building energy efficiency, infrastructure construction, and waste management. Mexico City has a particularly high capacity to implement urban GHG abatement strategies and policies in a coordinated way. For other municipalities, vertical coordination and national support will be essential.

Table 8. Proportion of 2050 urban abatement potential over which different levels of government have primary authority or influence

All abatement potential	Mt CO2e	% of total
Primarily local government	1,395	29%
Shared responsibility	896	19%
Primarily national/state governments	2,508	52%

All abatement except decarbonization of electricity	Mt CO2e	% of total
Primarily local government	1,395	46%
Shared responsibility	896	29%
Primarily national/state governments	764	25%

This means that national government have primary authority over 50% of total abatement potential and 25% when decarbonisation of electricity is excluded.

Policy priorities

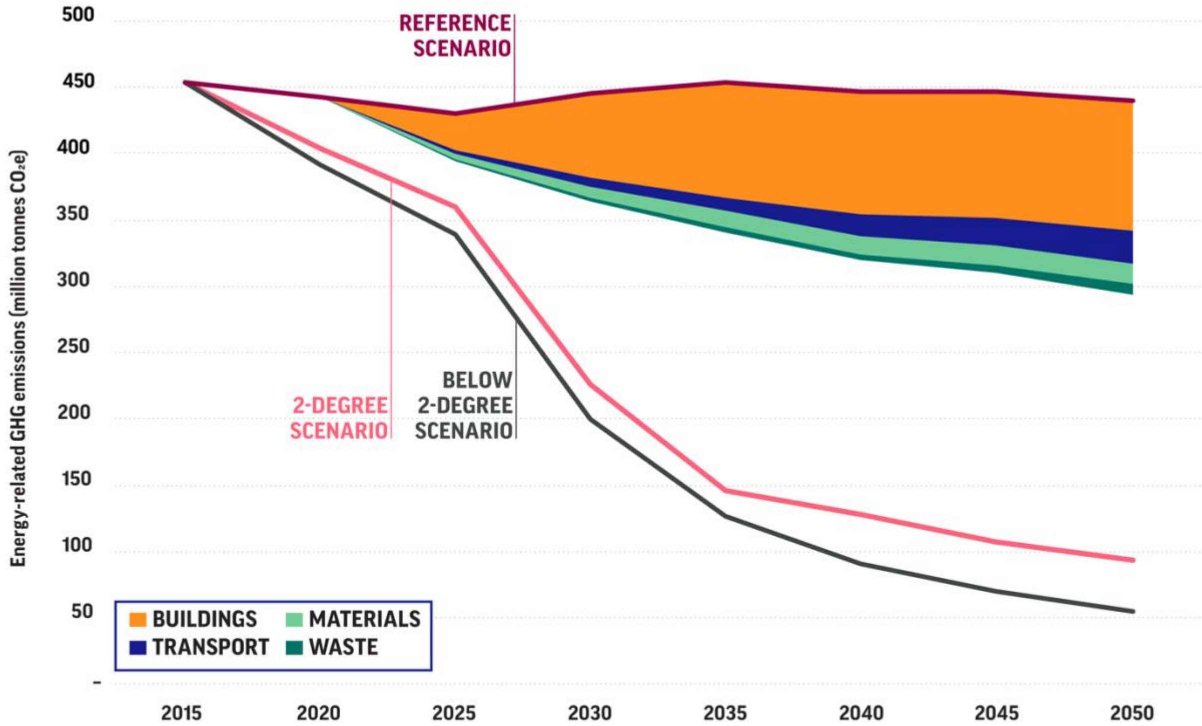
- **Aggressive electrification and efficiency improvements in residential and commercial buildings**. Our analysis suggests that buildings are a significant source of potential GHG abatement in Mexico. Electrifying energy end uses – including residential water heating and cooking – and improving their efficiency should continue to be major priorities.
- **Continued efforts to decarbonize the electricity sector**. To achieve deep reductions in GHG emissions, our model suggests that grid decarbonization will be an essential complement to efficiency and electrification efforts in the buildings sector. Efforts should include collaboration between state and municipal governments to expand adoption of distributed solar power.
- **Improving vehicle fuel economy.** IEA data suggest low average fuel economies for much of Mexico's vehicle fleet, compared to other OECD countries (IEA 2017). Federal efforts, complemented by local policies to improve fuel economy and accelerate adoption of electric vehicles could achieve a significant wedge of urban GHG abatement.
- **Limiting and reducing urban sprawl**. Mexico's National Urban Development Programme recognizes sprawl as one of the largest challenges facing urban development, and our model suggests significant potential for abatement strategies to reduce urban travel demand, including through more compact development. National policies that historically encouraged urban sprawl have been adjusted, but further efforts are needed at the local level to ensure the efficient movement of people and goods within Mexico's cities. Fully realizing the potential may require addressing capacity shortfalls to ensure that

municipal urban planning departments are fully staffed and funded, and transit systems are maintained and expanded accordingly.

SOUTH AFRICA

Altogether, our model suggests that actions to address GHG emissions from urban buildings, transportation, infrastructure construction, and waste could contribute up to 37% of the total mitigation in energy-related emissions needed between 2020 and 2050 in South Africa for a “below 2°C” scenario, as defined by the IEA (Figure 9). This is equivalent to over 40% of the mitigation needed for the IEA’s 2°C scenario for South Africa.

Figure 9. Potential contribution of urban GHG abatement in South Africa to Paris goals



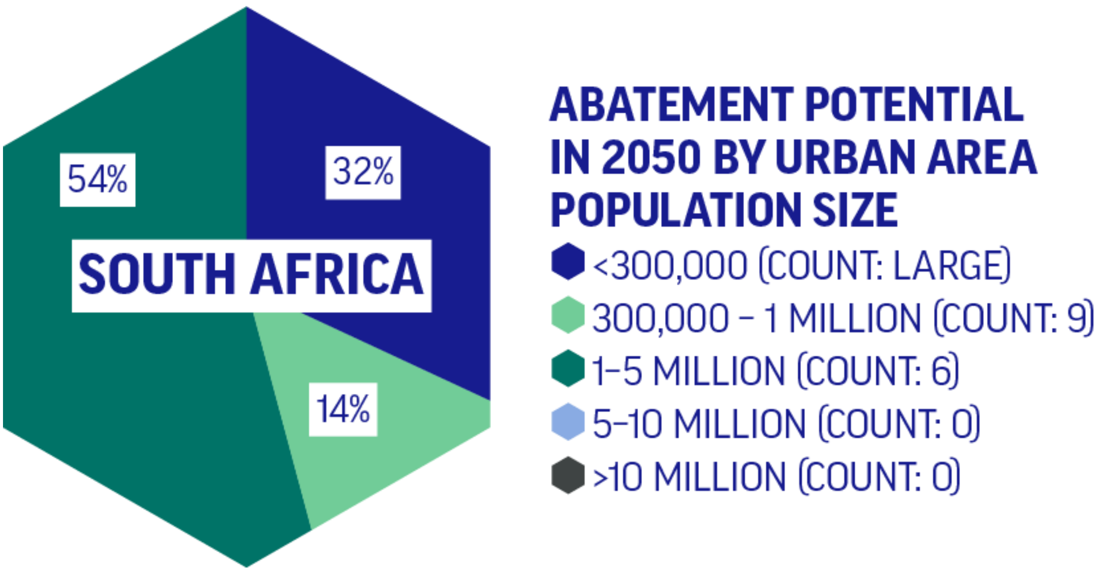
Opportunities for reducing energy use and improving energy efficiency are relatively evenly distributed across urban sectors in South Africa. If no efforts are made to decarbonize electricity, improving efficiency and reducing energy demand could reduce GHG emissions in 2050 by about 20 MtCO2e per year in the residential building, commercial building, and transportation sectors respectively. However, a major source of potential urban GHG abatement involves decarbonizing the electricity supply. A large majority of the emission reduction potential in the buildings sector, for example, is associated with decarbonizing electricity (Figure 9). Partly because of this, buildings comprise over 70% of the cumulative GHG reduction potential in South African urban areas between now and 2050 (Table 9).

Table 9. Cumulative modelled abatement potential by sector for South Africa, 2020-2050

Sector	$MtCO_2e$	%
Buildings	2,130	73%
Transport	351	12%
Materials	315	11%
Waste	115	4%
TOTAL	2,910	100%

Over half the abatement potential we modelled for 2050 could be achieved in just six major urban areas: Johannesburg, Cape Town, Ekurhuleni, Durban, Pretoria, and Port Elizabeth (Figure 2). At the same time, nearly one third of the modelled abatement potential would need to be realized in smaller urban areas of less than 300,000 residents.

Figure 10. South Africa GHG abatement potential in 2050 by urban area population size



Very few government functions are assigned exclusively to the municipal sphere. As a result, implementing major urban GHG abatement strategies in South Africa will require strong national leadership. At the same time, urban municipal governments have primary responsibility for some important mitigation measures, including in the areas of building energy use, electricity distribution systems, and waste management. Vertical coordination will therefore be decisive to unlock South African cities mitigation potential.

Table 10. Proportion of 2050 urban abatement potential over which different levels of government have primary authority or influence

All abatement potential	Mt CO2e	% of total
Primarily local government	412	14%
Shared responsibility	251	9%
Primarily national/state governments	2,248	77%

All abatement potential excl. decarbonisation of electricity	Mt CO2e	% of total
Primarily local government	412	29%
Shared responsibility	251	17%
Primarily national/state governments	778	54%

This means that national government have primary authority on 77% of total abatement potential and 54% when decarbonisation of electricity is excluded.

Policy priorities

- **Decarbonizing electricity**. Electricity generation in South Africa is still highly reliant on coal, and is a major contributor to total national GHG emissions. Strong national policy action will continue to be needed to reduce the carbon intensity of electricity to zero by 2050, as assumed in our "urban action" scenario. At the same time, national and local reforms are needed to improve the efficiency of urban distribution systems and remove barriers to the adoption of rooftop PV systems and other local renewable energy sources (SALGA 2015; Wolpe and Reddy 2015).
- **Continued electrification and efficiency improvements in residential and commercial buildings**. Aside from decarbonizing electricity, our analysis suggests that building efficiency and electrification measures offer the largest source of potential GHG abatement in South Africa's cities. Electrifying energy end uses – including residential water heating and cooking – and improving their efficiency should continue to be major priorities. Strong local policies are needed here, along with clear direction and allocation of responsibilities at the national level.
- **Improved urban spatial planning**. South African cities have suffered from poor spatial planning and a high dependency on cars (Wolpe and Reddy 2015) – a fact reflected in our estimates of potential GHG abatement associated with reducing travel demand and mode shifting. South Africa's Integrated Urban

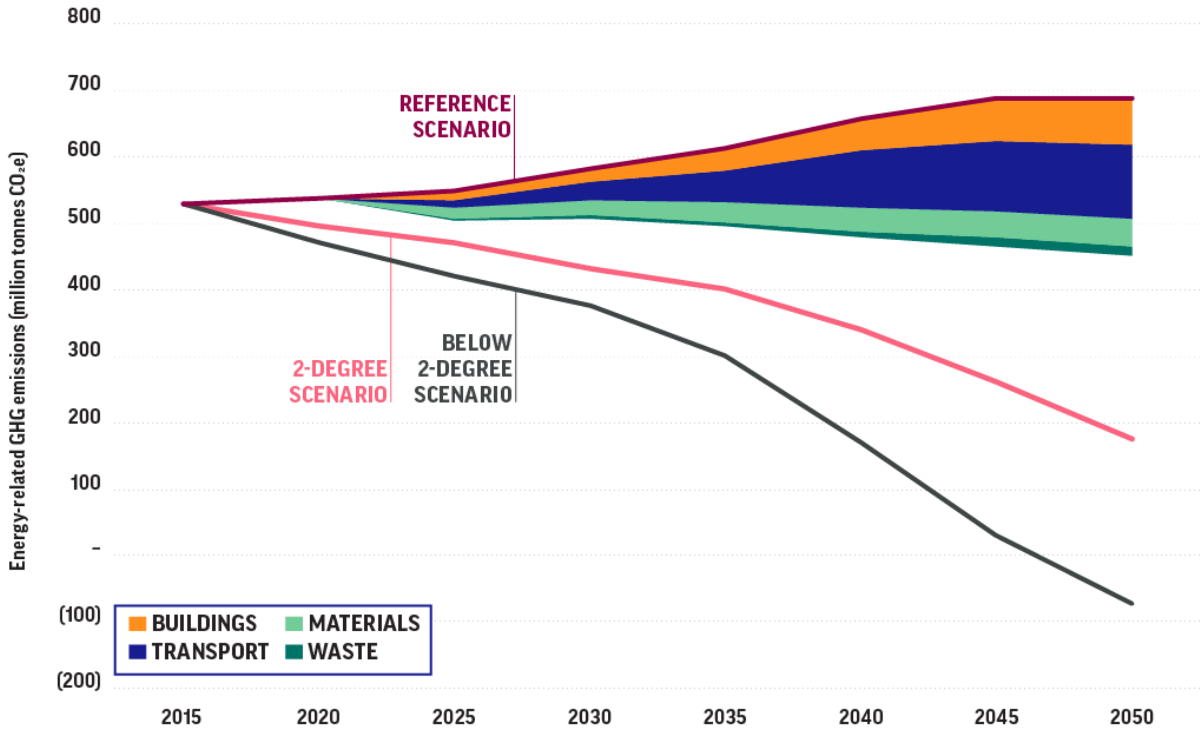
Development Framework calls for fixing these issues through compact city planning, green infrastructure, and public transit (COGTA 2016). Continued efforts are needed to see these goals realized at the local level, especially in new development as South Africa continues to urbanize.

- **Electrifying vehicles and switching to low-carbon fuels.** As indicated above, there is significant potential to reduce emissions from urban transportation through fuel economy improvements, greater adoption of EVs, and use of low-carbon fuels. Nationally led policies to improve fuel economies and promote ZEV adoption, combined with complementary local measures and incentives, are essential for realizing this potential.

BRAZIL

Altogether, our model suggests that actions to address GHG emissions from urban buildings, transportation, infrastructure construction, and waste could contribute one third of the total mitigation in energy-related emissions needed between 2020 and 2050 in Brazil for a "below 2°C" scenario, as defined by the IEA (Figure 11). This is equivalent to nearly 50% of the mitigation needed for the IEA's 2°C scenario for Brazil.

Figure 11. Potential contribution of urban GHG abatement in Brazil to Paris goals



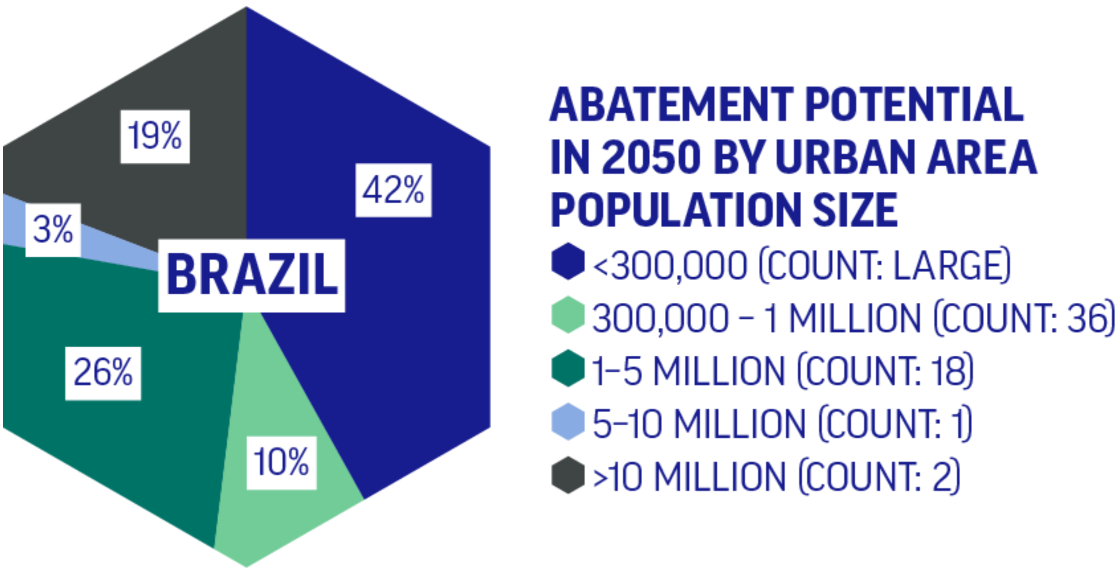
Although building sector GHG emissions (especially from residential buildings) are expected to increase more than in other urban sectors in the reference case, our model suggests that the largest potential for *reducing* emissions lies in the transport sector (Table 11). In part, this reflects Brazil's relatively heavy (though by no means exclusive) reliance on hydroelectricity for meeting energy needs in buildings, meaning that Brazil's building sector is already more decarbonized than is typical in other countries.

Table 11. Cumulative modelled abatement potential by sector for Brazil, 2020-2050

Sector	$MtCO_2e$	% of total
Buildings	1,095	28%
Transport	1,754	45%
Materials	833	21%
Waste	213	5%
TOTAL	3,895	100%

Over half the abatement potential would need to be achieved in urban areas with current populations of less than 1 million – including over 40% in smaller cities with fewer than 300,000 residents. This suggests the need for nationally coordinated policy efforts that will enable municipalities of all sizes to undertake abatement measures.

Figure 12. Brazil GHG abatement potential in 2050 by urban area population size



Policy priorities

- **Continued efforts to expand public transit, promote transit oriented development, and reduce motorized travel demand.** The Brazilian city of Curitiba pioneered the early development of bus rapid transit (BRT) systems, which have been widely adopted in Brazil and across the world. Nevertheless, many of Brazil's urban residents lack adequate access to public transit, and past efforts at urban development have unfortunately contributed to sprawl (Scruggs 2019). Our analysis confirms that redoubled national and local efforts to control sprawl, expand urban transit systems, and develop more walking and bicycling infrastructure could significantly curtail GHG emissions (Kahn and Brandao 2015; Lucon et al. 2015). These efforts could yield additional dividends in avoided infrastructure emissions. Improving freight logistics and intermodal connections could also make a significant contribution (Lucon et al. 2015).

- **Improving vehicle fuel economies and shifting to ZEVs.** Nationally led efforts to set more stringent vehicle efficiency and/or emissions standards, further develop low-carbon fuels, and establish incentives for hybrid vehicles and ZEVs will be essential for achieving deeper reductions in the urban transportation sector (Lucon et al. 2015). Municipal governments should complement these efforts, in particular through public procurement of ZEVs and low-carbon fuels, facilitating the development of charging infrastructure, and providing local ZEV incentives.
- **Electrification and efficiency improvements in residential and commercial buildings**. Improving building thermal integrity and electrifying or "solarizing" energy end uses – including space heating, water heating, and cooking – should continue to be major priorities. Improving building design and reducing the quantity of materials used in construction could play here, so federal policies should include efforts to improve coordination and enable effective standard-setting and enforcement across all cities.

Annex 1 – List of modelled mitigation strategies

Buildings	Transport	Infrastructure	Waste
Develop utility-scale zero-carbon electricity supply	Improve average fuel economy of motorized vehicles	Reduce energy and emissions intensity of materials production	Adopt waste reduction measures in manufacturing & use of products
Upgrade transmission & distribution systems	Increase market penetration of ZEVs	Promote more efficient building design and space usage	Increase recycling, waste diversion, and composting
Improve energy efficiency of heating & cooling equipment	Develop utility-scale zero-carbon electricity supply	Improve building construction and longevity	Promote or require capture and use of landfill methane for energy
Improve building thermal integrity	Upgrade transmission & distribution systems	Promote or require low-carbon cement blends and production processes	
Promote more efficient building design and space usage	Promote "smart grid" technologies and decentralized electricity supply	Promote compact, accessible, transit- and active transport-oriented urban development	
Improve energy efficiency of appliances, lighting, cooking, and water heating	Promote compact, accessible, transit- and active transport-oriented urban development	Expand and enhance public & mass transit systems	
Promote "smart grid" technologies and decentralized electricity supply	Increase operational efficiency of urban road network / transport systems		
	Expand and enhance public & mass transit systems		
	Develop low- and zero-carbon fuel supplies & infrastructure		

Annex 2 – Share of the modelled mitigation measures under each sector on which different level of government have primary authority for each country

China

	Local	Shared	National	TOTAL
Buildings	0	1	6	7
Transportation	0	1	8	9
Infrastructure	0	4	2	6
Waste	2	1	0	3
TOTAL	2	7	16	25
TOTAL SHARE	8%	28%	64%	100%

India

	Local	Shared	National	TOTAL
Buildings	0	2	5	7
Transportation	0	3	6	9
Infrastructure	0	2	4	6
Waste	0	3	0	3
TOTAL	0	10	15	25
TOTAL SHARE	0%	40%	60%	100%

Mexico

	Local	Shared	National	TOTAL
Buildings	4	0	3	7
Transportation	1	3	5	9
Infrastructure	3	1	2	6
Waste	3	0	0	3
TOTAL	11	4	10	25
TOTAL SHARE	44%	16%	40%	100%

South Africa

	Local	Shared	National	TOTAL
Buildings	3	2	3	8
Transportation	1	4	4	9
Infrastructure	1	3	2	6
Waste	3	0	0	3
TOTAL	8	9	9	26
TOTAL SHARE	31%	34%	35%	100%

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