UN environment programme

International Resource Panel

RESOURCE EFFICIENCY AND CLIMATE CHANGE

Material Efficiency Strategies for a Low-Carbon Future

Implications for Business Leaders in Housing and Mobility

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Implications for Business Leaders in Housing and Mobility

Resource Efficiency and Climate Change

Material Efficiency Strategies for a Low-Carbon Future

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About this document

This document highlights and contextualizes findings from the International Resource Panel report *Resource Efficiency and Climate Change: Material Efficiency Strategies for a Low-Carbon Future*. It provides a starting point for strategic decision-making for businesses in urban design, building and mobility. It has two concrete objectives:

- To highlight the key scientific findings and direct implications for business leaders of the above-mentioned IRP report.
- To contextualize the findings from said report with ideas from business for business about the economic opportunities of material efficiency strategies.

Key Messages

Credit: Flickr/CC BY 2.0/Carbon Visuals, One day's carbon dioxide emissions from above

The IRP Resource Efficiency and Climate Change (RECC) model shows that effective climate action must combine clean energy strategies with material efficiency strategies. It describes seven material efficiency strategies (Box 2) that hold great potential for climate change mitigation. These strategies may also enable lasting business success in housing and mobility markets, but this potential is still largely overlooked in climate and business debates. Business leaders will benefit from innovating in this field.

The IRP RECC report focuses on G7 countries, India and China as major global emitters, but the strategies are relevant globally.

The scientific findings have direct implications for business leaders:

1. Housing and mobility businesses can boost their climate performance with material efficiency strategies. These strategies have the significant potential to reduce life cycle emissions from homes in the G7 by 35-40 per cent, and by 50-70 per cent in India and China in 2050. For cars, these reductions could be 30-40 per cent in the G7 and 20-35 per cent in India and China.
2. The more intensive use strategy has distinct potential among the seven strategies. By avoiding underutilized floor space and underutilized vehicle capacity, this strategy reduces emissions from the material cycle and from the energy used in heating, cooling and transport. This strategy can deliver a share of over two thirds of the total emission reductions from material efficiency strategies.
3. It is time for all businesses to embrace fundamental business model transformations to fully benefit from material efficiency strategies. Business models that base their revenue on the performance of residential and mobility solutions over their life cycles can benefit from the savings and more innovative design of material efficiency strategies.
4. Material-efficient businesses need, and can support, determined policy development to create enabling market conditions. Important policy instruments include building codes and standards, green public procurement, virgin material taxes, recycled content mandates and the removal of virgin material subsidies.

In Chapter II, innovators in the business community provide ideas on the economic opportunities of material efficiency strategies.

Material efficiency strategies are essential in the effort to turn rising pressures into lasting business success. With consumers demanding more convenient and sustainable mobility and housing, with prices and price volatility of materials rising, with digitalization becoming the new normal, and with the devastating effects of the climate, nature and pollution crisis becoming more visible, lasting business success requires providing material-efficient services instead of resource-intensive products.

- In housing, material efficiency strategies can help:
  - Increase productivity of existing stock
  - Meet new demand and save costs in new construction
  - Meet the demand for new living services across old and new buildings
- In mobility, material efficiency strategies are essential in:
  - Meeting consumer demand for more convenient, affordable and flexible mobility
  - Capturing more value per vehicle
  - Staying relevant by meeting societal expectations of better socioeconomic performance and safety

To seize these opportunities, businesses can take several steps, with a focus on cooperation and promoting policy development:

- Anchor business visions in sustainable resource management and climate science.
- Invest in innovative pilots to determine scalable business models in material-efficient housing and mobility.
- Demand and support policies to create the market conditions necessary for material-efficient businesses to prosper. Reshape old and join new coalitions to overcome hurdles that cannot be tackled alone.

In the context of the COVID-19 pandemic and economic recovery in which this document is being written, material-efficient business models can identify important areas for recovery investments to boost economic activity and jobs while promoting a decoupled and more sustainable economy. At the same time, business models will need further refinements that consider infection prevention and resilience.

Content

Box 1. A note on terminology

- **Circular economy:** An economy where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimized (IRP 2020).
- **Decoupling:** When resource use or some environmental pressure either grows at a slower rate than the economic activity that is causing it (relative decoupling) or declines while the economic activity continues to grow (absolute decoupling) (IRP 2019b).
- **Decoupled business model:** A business model where revenue is increasingly independent of (i.e. decoupled from) growth in the quantity of virgin material inputs used throughout the value chain (IRP 2019a).
- **Energy measures:** Emission reduction solutions in energy production, e.g. renewable energy sources such as wind or solar, or in direct energy consumption including electrification or fuel switching as well as energy efficiency measures such as more efficient motors or housing insulation.
- **Material cycle emissions:** Emissions associated with producing and processing materials, including credit for replacing primary materials when recycling at the end of life of a product, and for the storage of carbon in wood (IRP 2020).
- **Life cycle emissions:** The emissions associated with the entire life cycle of a product, including material production, construction, operations and disposal. Includes credit for replacing primary materials when recycling at the end-of-life of a product, and for the storage of carbon in wood. also labelled as 'systems-wide' emissions. Here, they refer to the system-wide emissions associated with the production, operation, and disposal of the entire modelled product stock (IRP 2020).
- **Resource efficiency:** Efficient use of resources including materials, water, energy, biodiversity, land and, in the context of climate change, financial resources (IRP 2020).
- **Material efficiency:** The pursuit of technical strategies, business models, consumer preferences and policy instruments that would lead to a substantial reduction in the production of high-volume, energy-intensive materials required to deliver human well-being; expressed as a ratio of the amount of product or service obtained by unit of material use (IRP 2020).
- **Material efficiency strategy:** A unique approach to improve material efficiency across the system.
- **Rebound effect:** When improved efficiency affects demand and leads to an overall increase in consumption relative to a baseline and the benefits of efficiency are partially or fully negated through behavioural or systemic responses (IRP 2020, Chapter 3.5.4).

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I. The climate benefits of material efficiency

A. Material efficiency strategies in housing and mobility

The world has roughly 30 years to bring net greenhouse gas emissions to zero, and the curve of current trends must bend fast (United Nations Environment Programme 2019). We are therefore entering the make-or-break decade to make fundamental changes in how we live, move and do business.

Strong climate action is increasingly important for businesses to keep their customers and meet increasing regulation to decarbonise. It is also becoming crucial for investors as central banks have begun considering climate change as a risk to financial stability (Coppola *et al.* 2019; Shrikanth 2020; Townsend 2018).

Debates about emission reductions in industry have mostly focused on using cleaner energy from wind or solar technology, and on promoting energy efficiency, usually meaning the efficient use of fuel or electricity by industrial processes or the end users. While these energy measures are indispensable, they are not enough on their own to reach the goal set by the Paris agreement to keep the global temperature increase below 1.5oC (IRP 2020; IRP 2019c).

Global material production is responsible for about 23 per cent of global emissions today and rising fast. Using clean energy in these processes is relatively difficult. Adding solutions for reducing material consumption is crucial (IRP 2020).

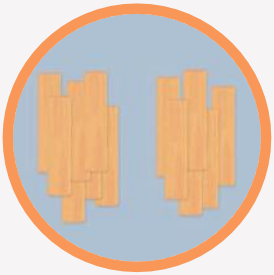
Material efficiency strategies reduce the need for materials (metals, cement and other non-metallic minerals, plastics, rubber and wood) in the provision of goods that provide the same or higher performance for customers and society. In residential buildings and passenger vehicles these strategies include the efficient use and reuse of materials as well as their more efficient operation. In addition, material efficiency strategies not only reduce the need for emissions-intensive new materials but can also reduce energy use for fuel and heating or cooling.

The IRP Resource Efficiency and Climate Change (RECC) model shows that effective climate action must combine clean energy strategies with material efficiency strategies (IRP 2020). Box 2 summarizes the seven material efficiency strategies for climate action.

Box 2. Seven material efficiency strategies for climate action

Using less material by design

Designing lighter and smaller products that deliver the same service, reduces the amount of materials incorporated in the product and often the energy required to operate the product as well. In this report, we address both the construction of lighter structures (less steel and concrete in the bearing structure of multifamily buildings) and the downsizing of vehicles, i.e., the shift from large vehicles (light trucks, sports utility vehicles) to smaller ones (passenger cars, minicars).



Material substitution

Replacing cement and steel with wood in buildings and steel with aluminium in cars can reduce life cycle emissions. The mechanisms of emission reductions vary. While wooden structures require less carbon in the construction and even store carbon, aluminium in cars causes an increase in material-related emissions but reduces operational energy use, resulting in a reduction of life cycle emissions.

Fabrication yield improvements

Reducing material scrap used in the fabrication and manufacturing process can decrease the demand for material input. For example, reduction of trimmings or amount of machining needed in car manufacturing.

Source: IRP RECC 2020

More intensive use

It implies that less product is required to provide the same service. In the case of vehicles, ride sharing (car-pooling) and car sharing imply that fewer vehicles are used more intensively to provide transport services to a given population. For buildings, both higher utilization rates, e.g., through shared housing, smaller, more efficiently designed residential units, and increased household size/cohabitation can achieve a reduction of building space required.

Enhanced end-of-life recovery and recycling of materials

This increases the amount or quality of secondary materials available, which can reduce the amount of primary materials used to produce the same or another product. More of the materials in homes and cars can be recycled but it may require more dismantling/deconstruction to avoid contamination of the different material flows.

Recovery, remanufacturing, and reuse of components

Replacing production of spare parts or even primary products. For example, I-beams of buildings can be reused.

Product lifetime extension

Through better design, increasing repair, and enhancing secondary markets. For example, the lifetime of buildings can be enhanced through flexible design which makes it easier to modify interior walls, thus accommodating changing use patterns.

In 2015, construction and manufacturing each accounted for 40 per cent of global material-cycle greenhouse gas (GHG) emissions, which are the emissions from the extraction and processing of materials, minus credits for recycling and carbon storage. Residential buildings are responsible for the largest share of construction-related emissions, and cars for the largest share of emissions related to manufacturing. Material efficiency strategies have significant potential to contribute to the reduction of GHG emissions in the housing and mobility sectors (IRP 2020).

The IRP RECC model shows that the material efficiency strategies in Box 2 could reduce 2050 emissions from the material cycle of old and new residential buildings in the G7 by at least 80 per cent. In China, the potential reduction is similar, and in India a bit smaller while still over 50 per cent. For passenger cars, these strategies could reduce material cycle emissions by 57-70 per cent in G7 countries and 29-62 per cent in China and 39-53 per cent in India (Figure 1 and Figure 2, see orange areas) (IRP 2020)

In addition, material efficiency strategies not only reduce the volume of materials used and their related emissions, but also help reduce ongoing energy use – fuel used in cars and energy used for heating or cooling in homes – particularly through the more intensive use strategy (IRP 2020)

The seven material efficiency strategies together could reduce annual life cycle emissions from homes in 2050 by 35-40 per cent in the G7, and in China and India by as much as 50-70 per cent (Figure 1).

Box 3. A note on the IRP RECC model

The IRP RECC model compares two future scenarios for the 2016–2050 period. The reference scenario without material efficiency strategies (middle bars in Figures 1 and 2) projects the development of emissions for homes and passenger cars with implementation of energy measures only. The material efficiency scenario (right bars) projects how emissions will develop if energy measures and all material efficiency strategies are implemented. The additional reductions through material efficiency strategies are significant, albeit not enough to stay within the 1.5°C limit, which calls for net zero global emissions by 2050. Hence, both energy measures and material efficiency strategies must be implemented even more widely and deeply than what the IRP RECC model suggests. For complete descriptions of the assumptions and the model, please refer to the full report at www.resourcepanel.org/reports/resource-efficiency-and-climate-change.


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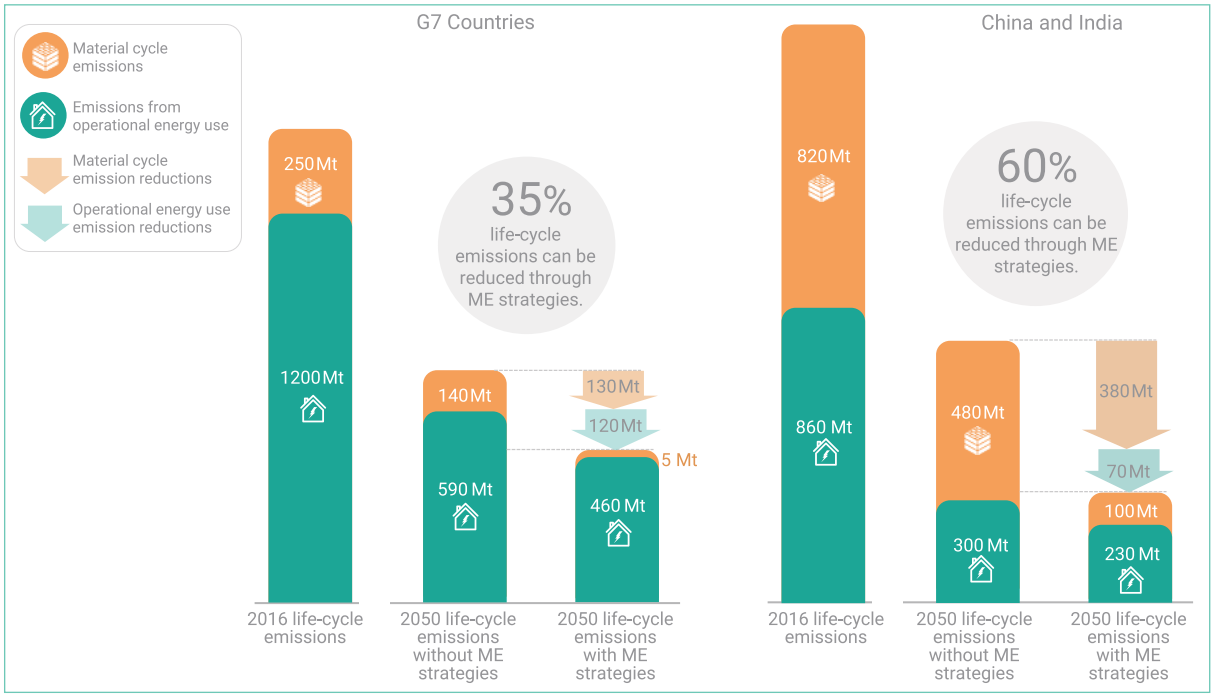
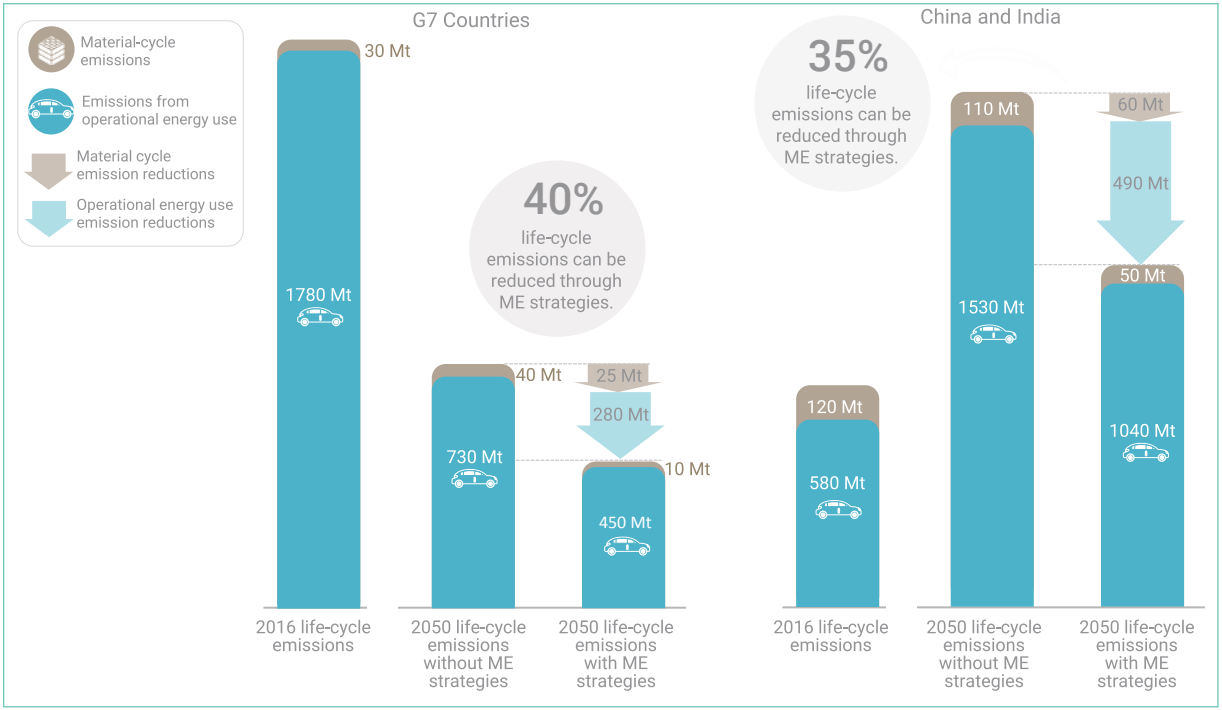
Figure 1. Life cycle emissions from homes with and without material efficiency strategies in 2050 in G7 countries, China and India



Source: IRP RECC 2020

Reductions in life cycle emissions from cars in 2050 would be 30-40 per cent in G7 countries, and 20-35 per cent in India and China (Figure 2). These reductions are in addition to the emission reductions that come from the anticipated shift towards electric and fuel cell vehicles and decarbonization of the electricity mix. This document focuses on housing and mobility, but similar strategies are likely to be valid for other material-intensive sectors.

Figure 2. Life cycle emissions from cars with and without material efficiency strategies in 2050 in G7 countries, China and India



Source: IRP RECC 2020

Credit: Pavel Vinnik/Shutterstock.com

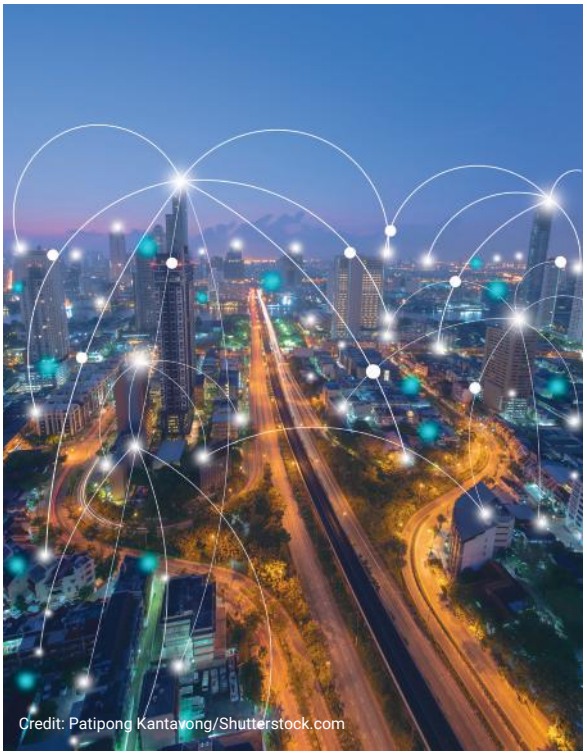
B. The distinct potential of the more intensive use strategy

Of the seven material efficiency strategies modelled by the IRP, more intensive use has the highest potential to reduce emissions in G7 countries. This strategy reduces material cycle emissions—from raw materials extraction and manufacturing—and emissions from fuel use in cars and heating and cooling in homes.

In principle, the more intensive use strategy reduces floor space per capita across the housing stock of a country or reduces the number and size of cars while providing a similar or better level of service (Box 2). On-the-ground studies and experimentation are required to take advantage of this strategy in practice, particularly in the housing sector where the stock is slower to change.

Several approaches to more intensive use are, however, already known or plausible, and provide a starting point for innovation. New forms of car-sharing and ride-pooling services are becoming increasingly popular in cities. More intensive use in housing can mean that people move into space-appropriate residences, downsizing or upsizing with changing family size. Such movements would open space for growing families that need more room, precluding the need for new buildings and hence saving materials, and would also mean that less underused space would be needlessly heated. Multiparty residences (housing for two or more families), such as flats in apartment blocks, tend to be much more space efficient than single family residences, and more heating efficient as walls are shared. In addition, multiparty residences not only save materials and heating, they also provide the possibility of reducing urban sprawl and commutes, which are big factors for emissions and can be detrimental to the economic performance of a city.

Moving towards more intensive use usually requires businesses to provide a different service and consumers to live or move differently, and so requires vision and incentives. Information technology can enable or enhance the opportunities to move in this direction, and businesses will need to innovate in close interaction with consumers.



Credit: Patipong Kantavong/Shutterstock.com

While more intensive use is important, businesses should combine this strategy with other material efficiency strategies, such as material substitution or recycling, to realize the synergistic potential.

The following sections summarize the mitigation potential as modelled by the IRP.

1. The climate mitigation potential of more intensive use and other strategies in homes

A 20 per cent reduction in floor space in G7 countries (compared to the reference scenario of 2050) would result in about a 30 per cent reduction of the annual life cycle emissions from homes in 2050. This significant saving is in addition to energy measures such as improving low-carbon heating supply and insulation. The model also tells us that cumulatively for the years from 2016 through 2060, more intensive use could reduce emissions by about 15 per cent, or more if implemented faster. This reduction represents over three quarters of the total reduction potential through material efficiency (see purple area in Figure 3) and makes this strategy a priority for climate action for business leaders in G7 countries.

In China, more intensive use represents roughly half of the potential material efficiency savings, and in India roughly one quarter (Figure 3). India already has a very intensive use of its limited floor space. More intensive use does not mean a reduction from current levels, but only that floor space would grow more modestly than in the reference scenario. In developing countries, the greater need for new buildings – as opposed to working with the existing building stock – suggests that developers and construction businesses should pursue material efficiency strategies that make new construction more efficient. These strategies may include material substitution (for example with sustainable timber) using less material by design – leaner walls and beams, for example – and pursuing fabrication yield improvements through modular offsite fabrication.

In G7 countries with large existing housing stocks and shrinking populations, reducing floor area through more intensive use means demolishing some obsolete buildings. This is where an opportunity to combine strategies comes in. Businesses specializing in enhanced end-of-life recovery and recycling and in recovery, remanufacturing and reuse of components will be needed to enhance more intensive use strategies. These businesses can take care of deconstructed material and components, and design refurbishments and new buildings that use recovered material. Businesses and developers should intensify the use of energy-efficient and modular refurbishments or new buildings.

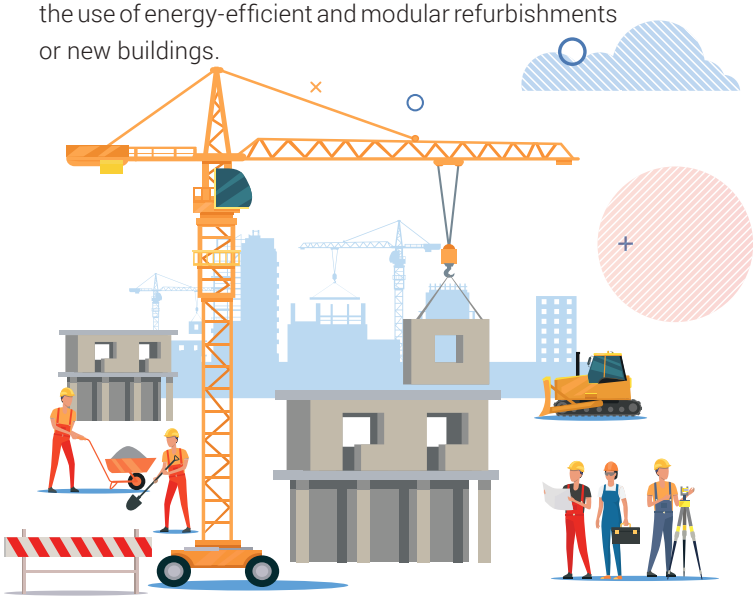
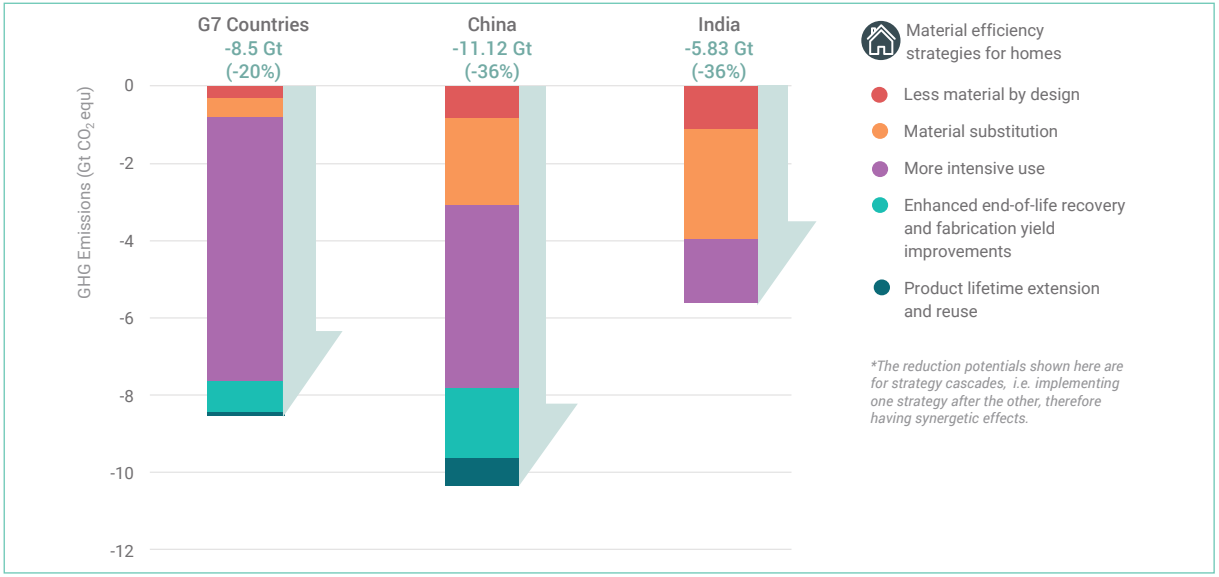


Figure 3. Potential GHG savings per material efficiency strategy for homes, cumulative 2016-2060



Note: These figures show cumulative reductions from 2016 through 2060 in comparison with the reference scenario, while figures 1 and 2 show annual reductions in 2050. The relative importance per strategy is similar in annual or cumulative perspectives.
Source: Adapted from IRP RECC 2020


Credit: Jason Finn/Shutterstock.com

2. The climate mitigation potential of more intensive use and other strategies in cars

In the G7, more intensive use of cars could reduce annual life cycle emissions in 2050 by about 31 per cent and cumulatively for 2016-2060, by about 15 per cent, or more with faster implementation (car-sharing and ride-sharing; see light and dark purple areas in Figure 4). More intensive use represents about two thirds of the total reductions possible through material efficiency, a clear priority for action.

This 15 per cent reduction could be achieved if 25 per cent of all trips were conducted as shared rides and 15-25 per cent of cars in the fleet were shared vehicles by 2050. Car-sharing and ride-sharing, produce positive efficiency effects because they increase the number of people using a car at the same time or over a period of time. Individual 'taxi-type' ride-hailing services do not currently show a net positive efficiency effect given low occupancy and empty trips to the pickup point.

In China and India, life cycle emissions from car fleets are projected to rise from today's levels even with ambitious energy and material efficiency measures. Material efficiency, however, along with electrification, can reduce the emission growth rate. More intensive use plays the largest role in achieving this. Business leaders should promote shared mobility models, which can also significantly contribute to better traffic functioning and reduced air pollution, especially when complementing public transport.

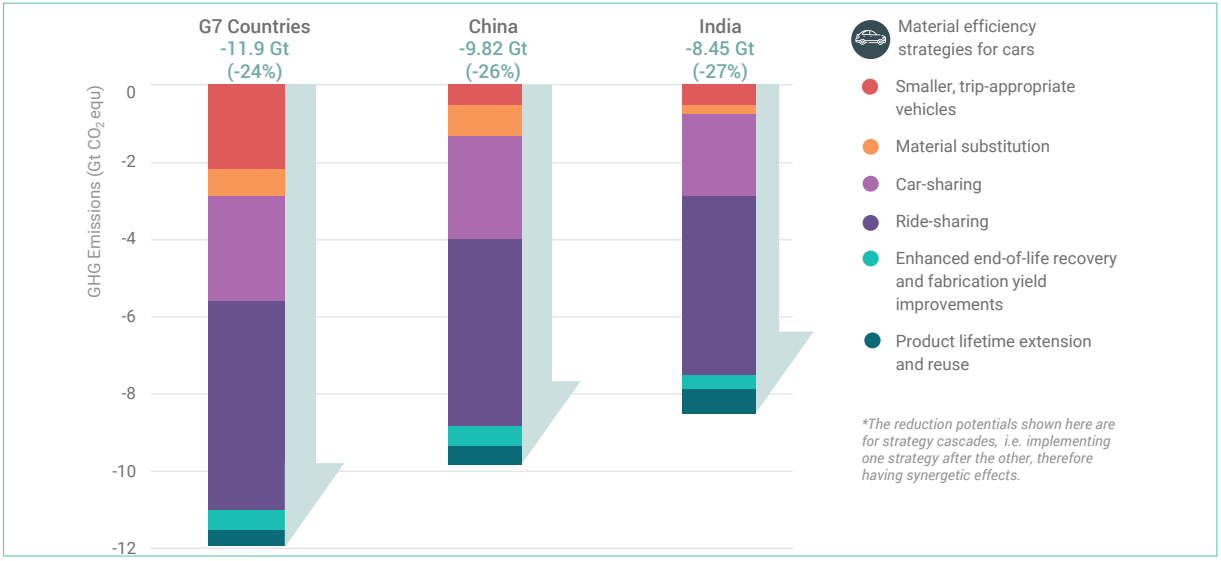
The modelling makes conservative assumptions about the level of sharing. The technical possibility and market importance are much higher. Business leaders should therefore aim for a faster and more ambitious intensification use rate per vehicle.

In populated areas, buses and railways could achieve higher energy and material efficiencies than private cars, even if the cars are shared. Business leaders must, therefore, plan shared cars as complementary, and likely best in cooperation, with mass transit providers within a strategic densification scheme[1].

Credit: Sebastien DURAND/Shutterstock.com

1- According to the IRP, strategic densification is "the process of intensifying the number of jobs/people/amenities located within a network of primary and secondary high-density nodes that are well-connected by efficient and affordable mass transit systems (bus, rail, nonmotorized)". See IRP (2018).

Figure 4. Potential GHG savings per material efficiency strategy for cars, cumulative 2016-2060



Note: These figures show cumulative reductions from 2016 through 2060 in comparison with the reference scenario, while figures 1 and 2 show annual reductions in 2050. The relative importance per strategy is similar in annual or cumulative perspectives.
Source: Adapted from IRP RECC 2020

Box 4. Authors' perspective on COVID-19

In the context of the COVID-19 pandemic, risk assessments and design must be refined when it comes to denser residential housing and shared mobility.

More intensive use in housing does not mean cramped housing or further density in already overly dense residential areas. Implementing this strategy eliminates underutilized spaces or puts it to better use and creates more efficient and more flexible housing structures. In principle these measures would enable higher quality housing for more people and provide opportunities for community interactions in a well-organized – and safe – manner. If necessary, isolation at home should be possible and even easier, given the higher quality of well-designed and well-maintained, possibly serviced, housing structures. Essential services could be better accessed in more compact neighbourhood set-ups, ideally designed with a well-balanced mix of residential, public and commercial spaces.

For shared vehicles, considerations are potentially more complex given the size of vehicles – and measures to design pandemic-proof shared mobility systems warrants further discussion. Mobility has gone down in all forms during the lockdowns, and customers have been cautious of shared mobility (McKinsey & Company 2020b). Most shared cars or even pooling services, however, are flexible enough to be used individually and can provide alternatives to mass transit options for key workers without obliging people to buy their own car in times of crisis. Some mobility providers have even offered discounts for key workers during the peak of the pandemic in 2020 (CoMoUK 2020). Early observations suggest that with sanitary safety measures in place, shared mobility will likely see a renewed demand from customers soon (McKinsey & Company 2020b). Businesses would do well to look beyond car mobility though, as bicycle and scooter services seem to be in high demand (McKinsey & Company 2020a). Integrated mobility planning tools, and the businesses providing related solutions, are likely to become more important. Flexible mobility systems and booking platforms that respond to social distancing requirements will likely become important in the longer term (WEF 2020).

Credit: Mila Supinskaya Glashchenko/Shutterstock.com

3. Fundamental transformation of the business model

There are many opportunities to improve material efficiency over the life cycle of homes and cars. A business model focused on one-off sales of products will not often capture these gains. A business model making revenue from the performance of a product or service over a longer period will. Thus, many businesses need to change to a service-based model that charges for the long-term functionality of homes and cars rather than the sale of the product, incentivizing the minimization of resource use for the duration of the service, an approach dubbed "decoupling business models" (IRP 2019a).


Credit: rodho/Shutterstock.com

C. Policy action for material-efficient businesses

Much of the required shift in business models needs favourable policy conditions, particularly to achieve a transition at scale. The extensive IRP RECC policy review identifies a gap of material efficiency policies in the G7. Current policy and market conditions are not incentivizing the uptake of material efficiency strategies, and in some cases even actively disincentivizing them.

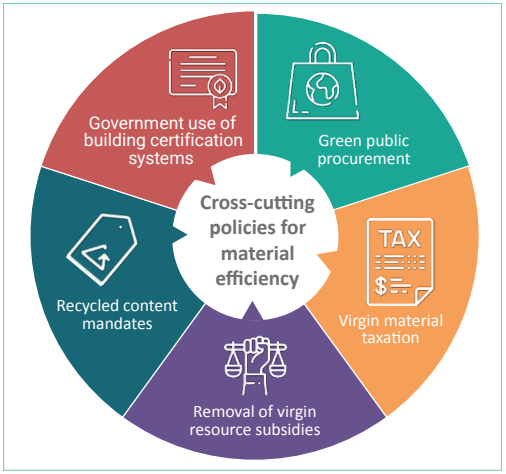
In some North American cities, regulations limit construction permits to single-family houses preventing the construction of efficient modern multiparty residences. Few building codes promote the use of lightweight structures, material substitution, modular building components, deconstruction or recycling. In the vehicle sector, some policies encourage car-sharing to reduce congestion and material recycling to reduce waste, both of which provide useful experience for further policy development. But few policies target more intensive use systematically as a climate mitigation measure or focus on reducing the absolute material cycle emissions in car design.

Worse yet, policy measures such as subsidies for virgin resource extraction are skewing the market against efficiency, artificially lowering the price of virgin materials and limiting the value of potential material savings. Overall, the IRP RECC policy review suggests the need for a life cycle approach to policy design and monitoring. It is tempting to focus on material efficiency policies only at end of life, but the climate change benefits are most likely to be harnessed effectively if policies are developed and evaluated using a life cycle approach.

Increased intensity of use shifts the focus of policy from choice and use of materials to lifestyle choices. Policy instruments such as taxation, zoning and land-use regulation play a role, but so do consumer preferences and behaviour. Cross-cutting policies could have significant impacts on material efficiency. Such policies include building codes and standards green public procurement, recycled content mandates, virgin material taxation and removal of virgin resource subsidies.

Fiscal policy instruments are important in minimizing the rebound effects of monetary savings leading to an increase in consumption. Policy instruments that directly or indirectly raise the cost of production or consumption such as taxes or cap-and-trade systems can reduce rebound effects. While politically challenging, the reduction of subsidies for virgin resources is likely to provide dual benefits – increased material efficiency and government revenues. Moreover, material efficiency measures could be integrated into national planning, including in the Nationally Determined Contributions of the Paris Agreement (NDCs). Figure 5 summarizes important overarching policy instruments identified by the IRP 2020 report.

Figure 5. Cross-cutting policies to improve material efficiency and integration with climate policies



Source: IRP RECC 2020 Summary for Policymakers

Business experimentation, evaluation and regular exchange with policymakers will be key elements in informing policy design that increases efficiency, avoids rebound effects and can be implemented at scale by innovative companies.