Materials & The Carbon Footprint of the Economy

Edgar Hertwich

International Institute for Applied Systems Analysis

and XIO Sustainability Analytics

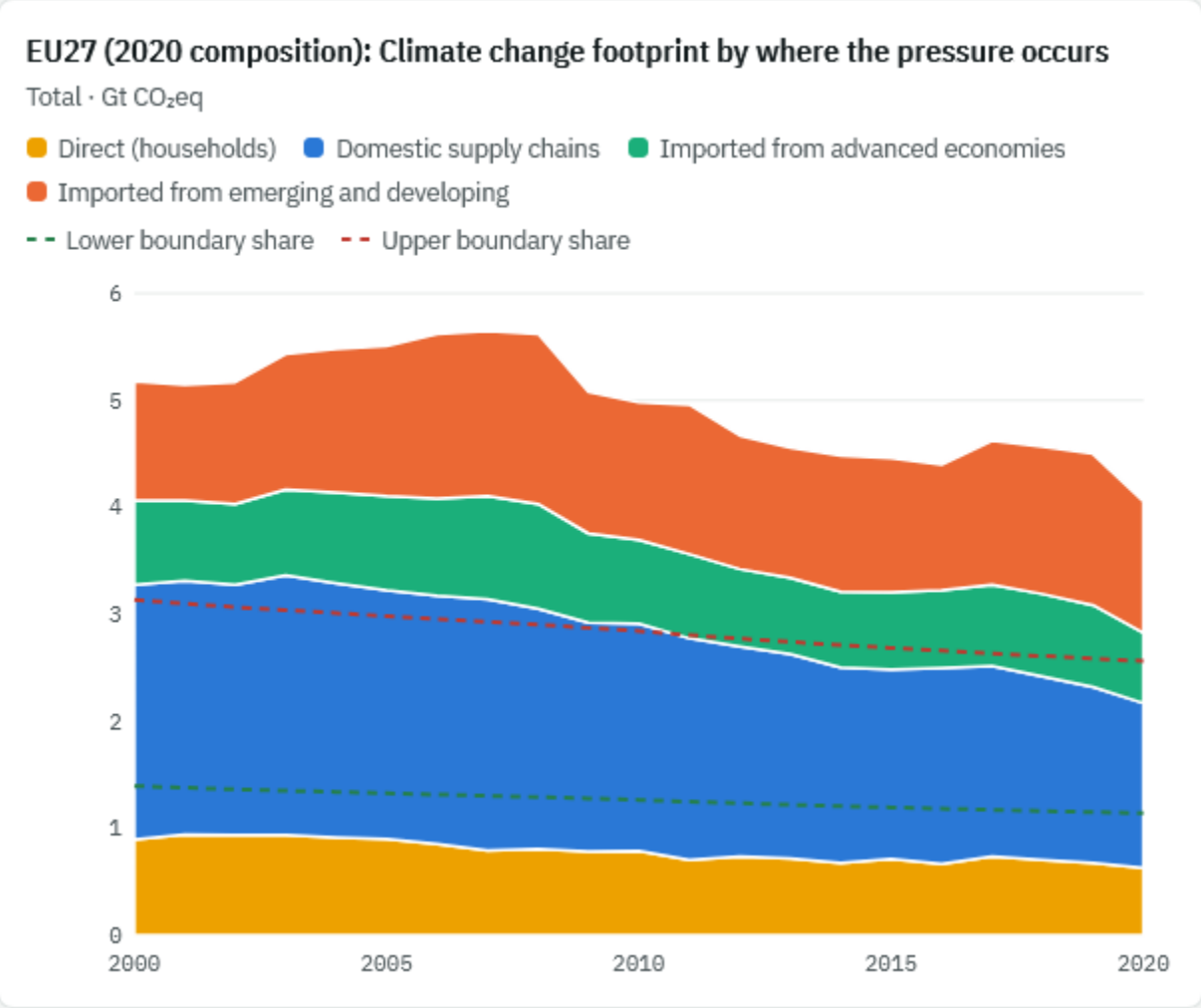
Competitiveness within a Safe and Just Operating Space
Luxembourg, 20 Oct. 2026

Key messages

- Our consumption is enabled by resource extraction and pollution all over the world
- Material production causes about ¼ of GHG emissions and mostly serves capital formation
- Demand-side and structural efficiency measures can reduce GHG emission from materials production – ‘the circular economy’
- Utilization, design, and lay-out are important
- Collective solutions bring multiple benefits

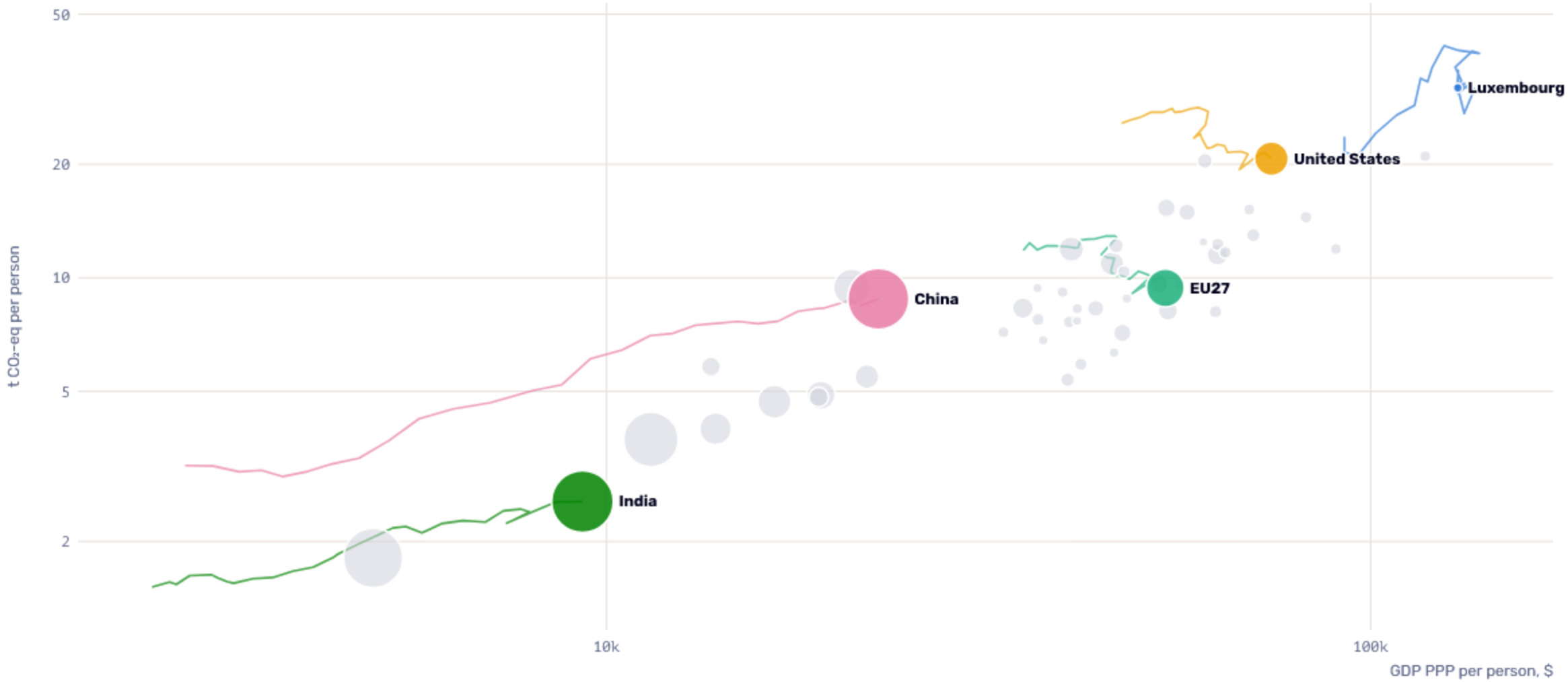
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Consumption is enabled by resource extraction and pollution all over the world



GHG emissions per person against income, 2023

consumption-based footprint • both axes logarithmic • circle area follows population

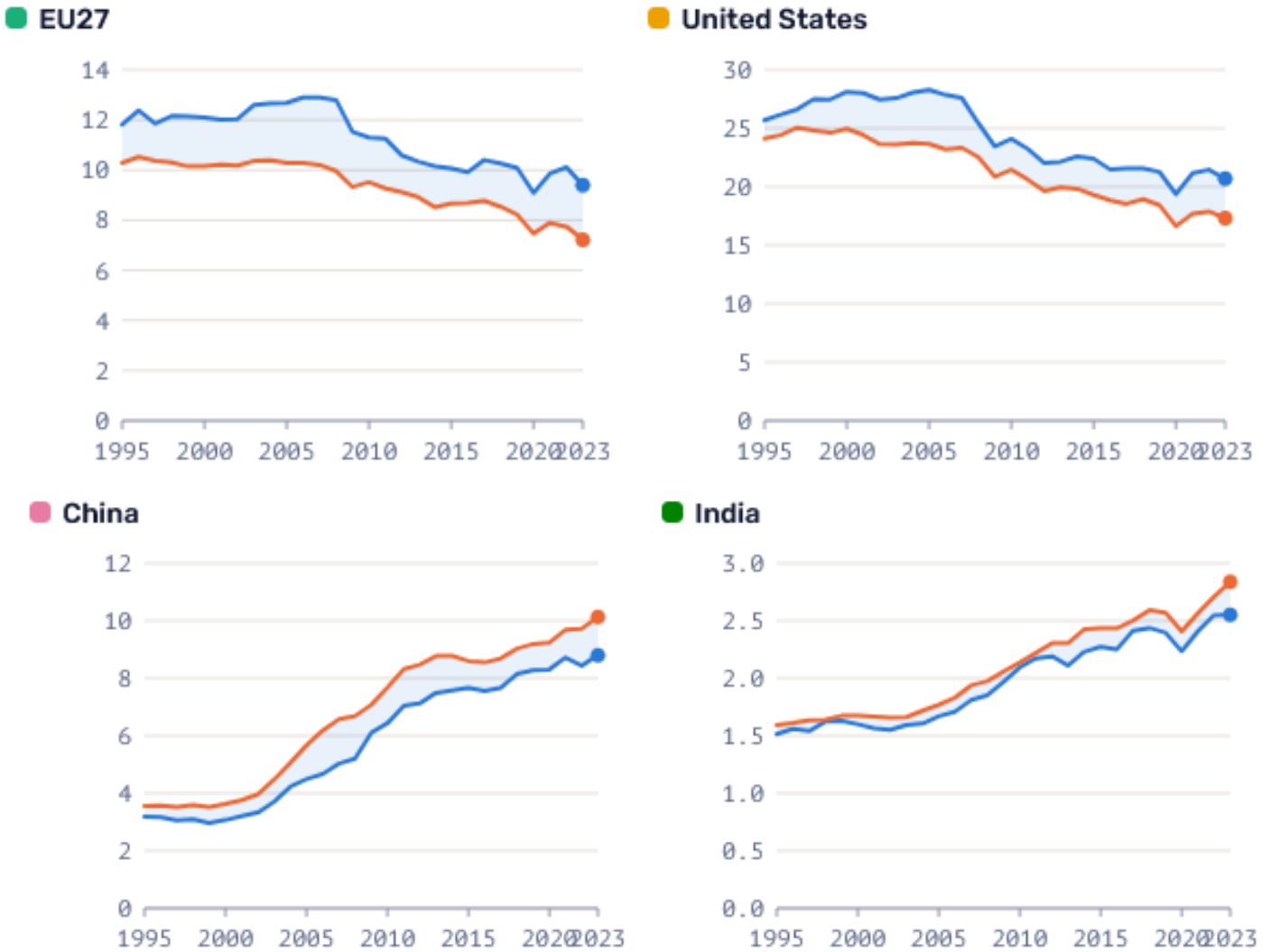


https://www.xio-sa.com/footprint-explorer

GHG emissions: production and consumption

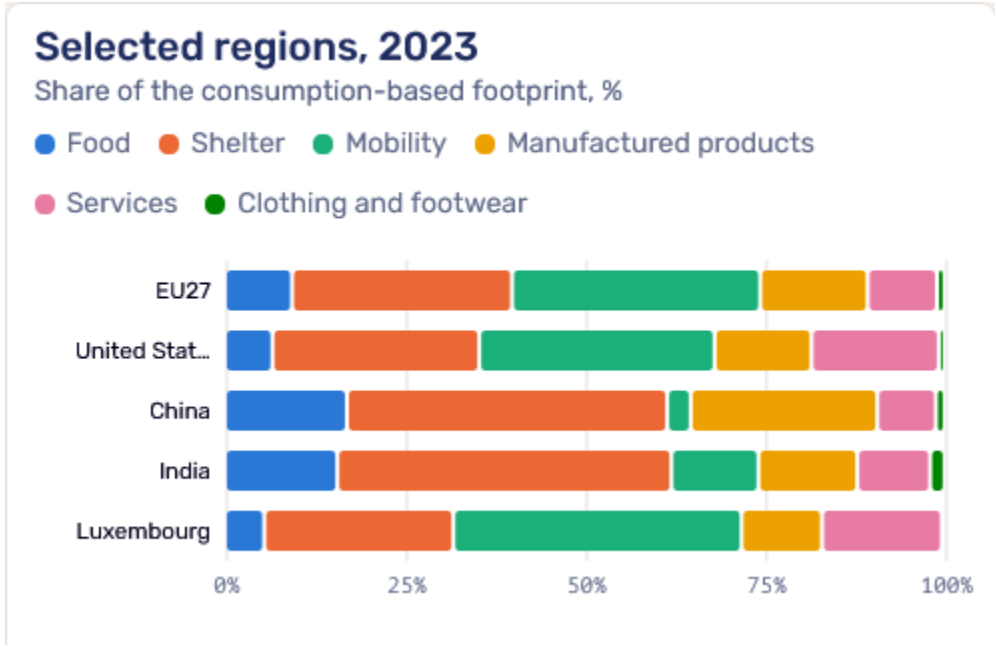
Per capita • t CO_2-eq per person

Consumption-based (CBA) Production-based (PBA)

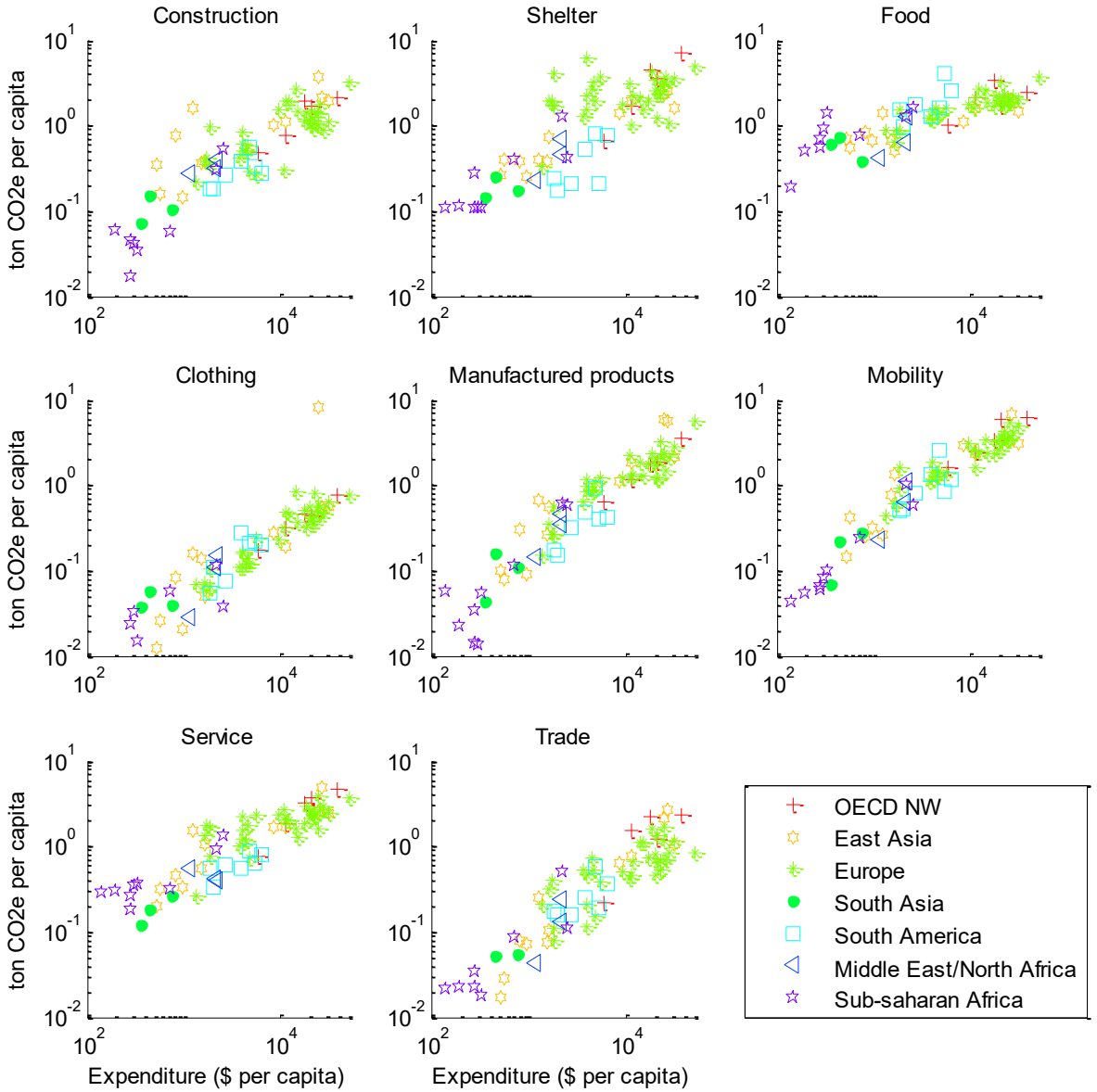


https://www.xio-sa.com/footprint-explorer

What consumption?



https://www.xio-sa.com/footprint-explorer



Hertwich, Peters (2009) The Carbon Footprint of Nations, *ES&T*

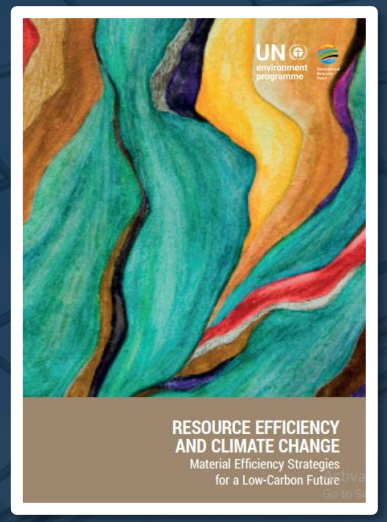
UN environment programme

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RACE TO ZERO

RESOURCE EFFICIENCY AND CLIMATE CHANGE:

Material Efficiency Strategies for a Low-Carbon Future

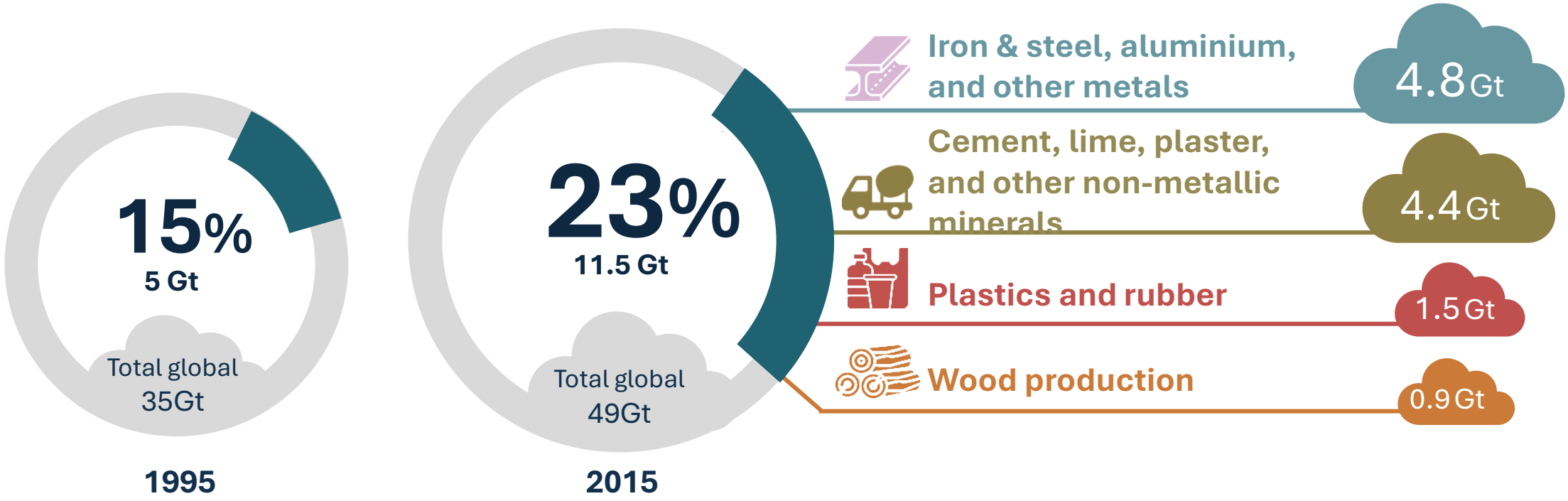


Lead authors and IRP Members

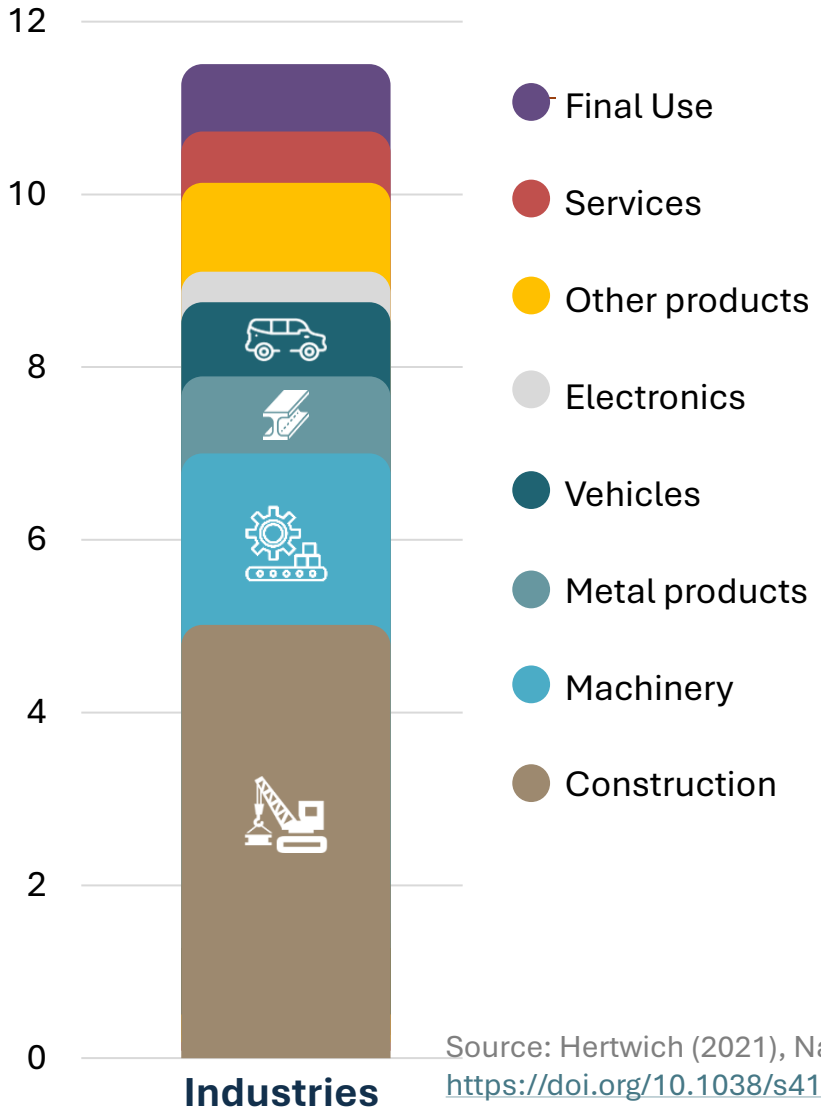
- **Edgar Hertwich**
- **Reid Lifset**

The production of materials causes 23% of global GHG emissions

Global GHG emissions from a value-chain perspective



IRP report focuses on high-relevance housing and cars as examples

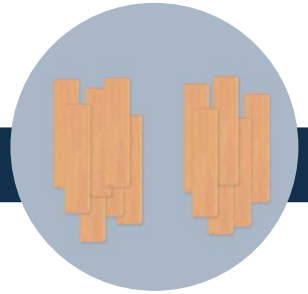


Source: Hertwich (2021), Nature Geoscience
https://doi.org/10.1038/s41561-021-00690-8

Report assesses seven crucial Material Efficiency Strategies to reduce emissions



Using less material by design



Material substitution



Fabrication yield improvements



More intensive use



Product lifetime extension



Recovery, remanufacturing, and reuse of components



Enhanced end-of-life recovery and recycling of materials

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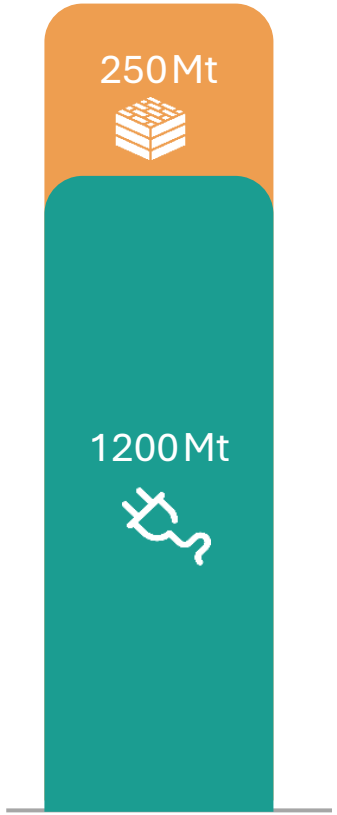
@UNEPIRP #ResourceEfficiency4Climate

Download the report: bit.ly/IRPrecc

Material Efficiency (ME) Strategies can reduce **35-40%** of lifecycle emissions from **homes** in **G7 countries** in 2050

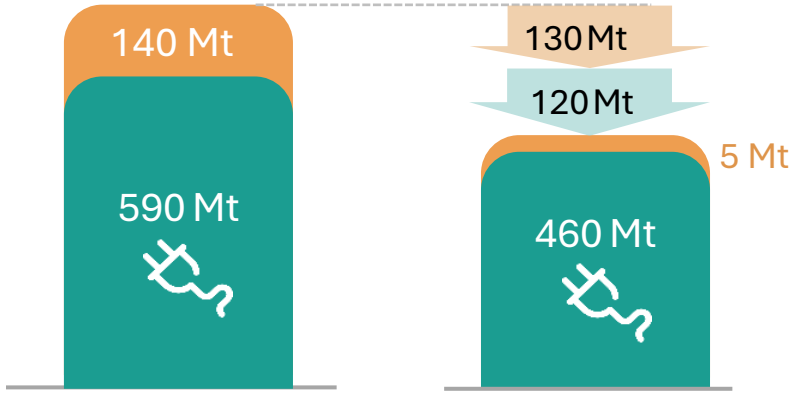
- Material cycle emissions
- Emissions from operational energy use
- Material cycle emission reductions
- Operational energy use emission reductions





2016 life-cycle emissions

35% life-cycle emissions can be reduced through ME strategies.



2050 life-cycle emissions **without** ME strategies

2050 life-cycle emissions **with** ME strategies

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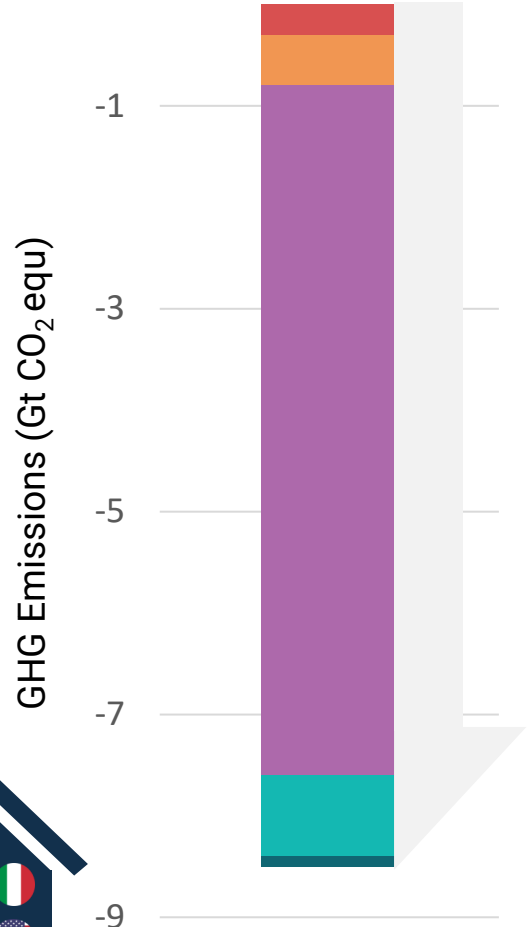
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More intensive use and **recycling** are the most important strategies

Potential GHG savings from material efficiency strategies for homes in G7 (2016-2060)



- Using less material by design
- Material substitution
- More intensive use
- Enhanced end-of-life recovery and fabrication yield improvements
- Product lifetime extension and reuse

**The reduction potentials shown here are for strategy cascades, i.e. implementing one strategy after the other, therefore having synergetic effects.*

Most of the strategies reduce predominantly material related emissions

Some affect materials and operational energy use

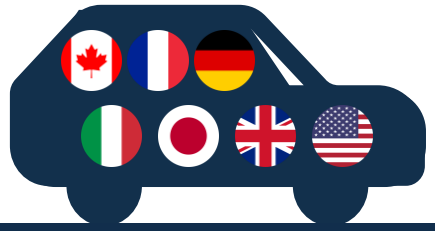
✓ **More intensive use reduces materials and heating/cooling needs**

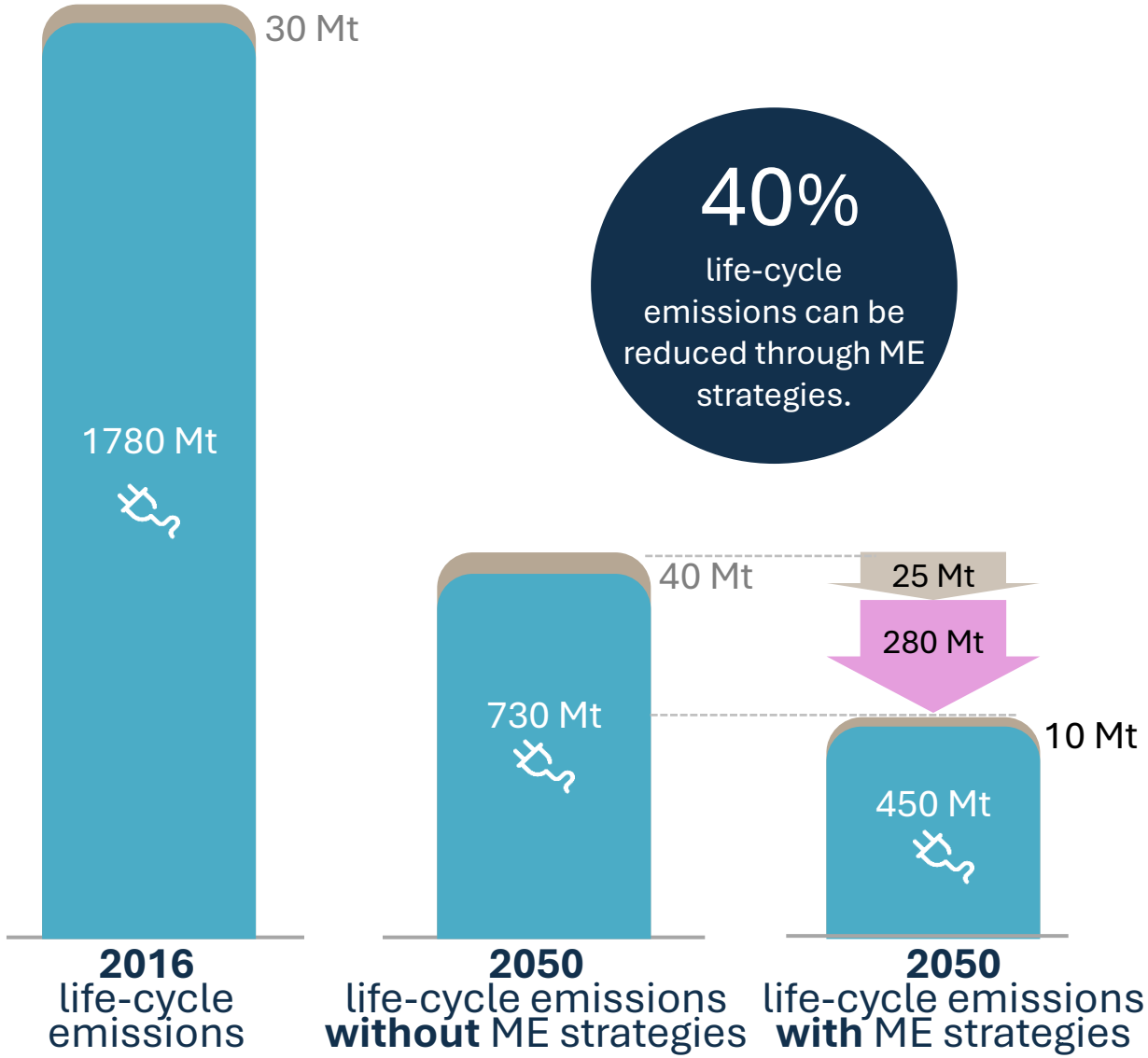
✓ **Material substitution (wood instead of cement) can increase energy use**

Ca. 20% cumulative savings

Material Efficiency Strategies can reduce **40%** of lifecycle emissions from **cars** in **G7 countries** in 2050

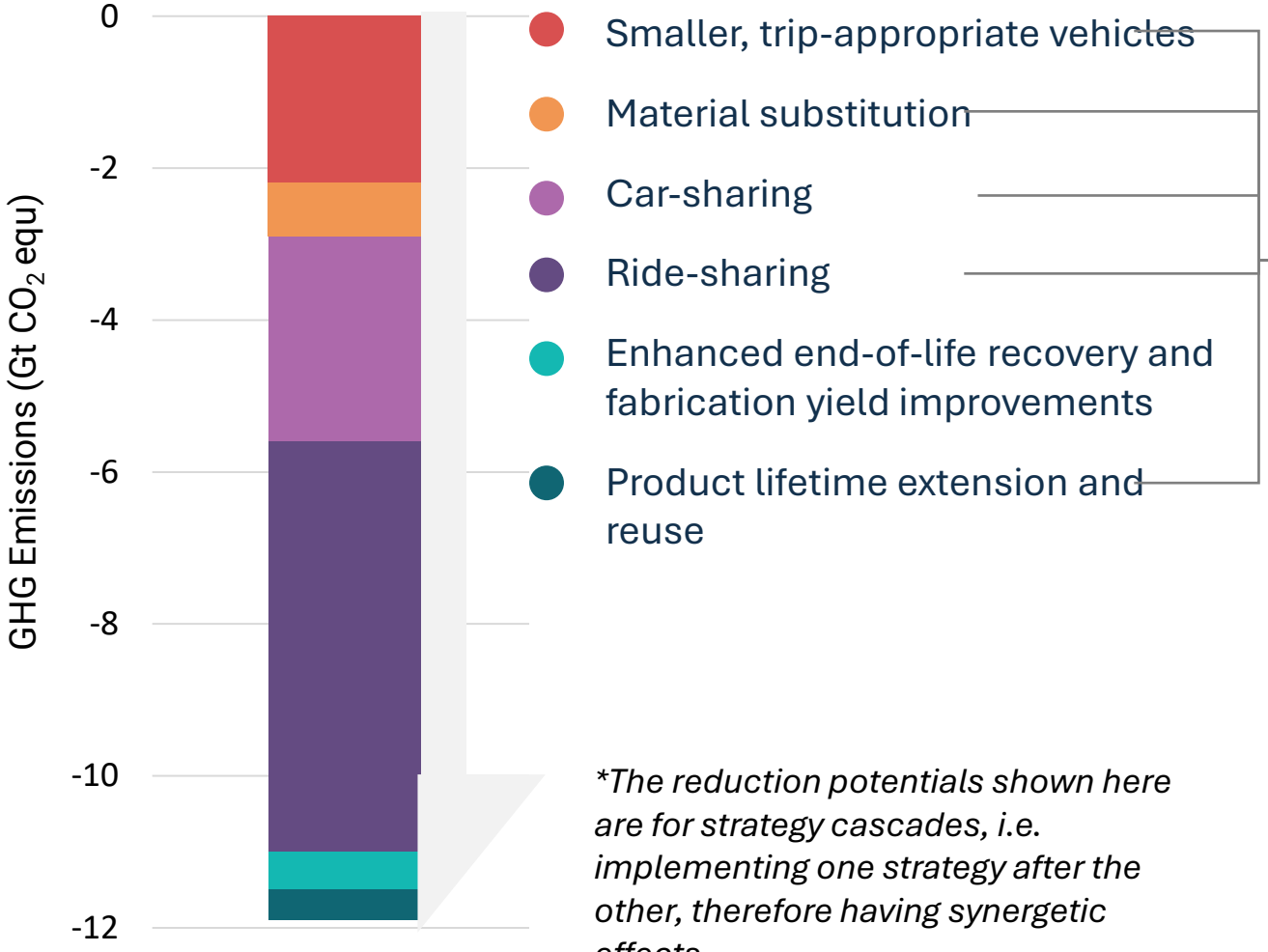
- Material cycle emissions
- Emissions from operational energy use
- Material cycle emission reductions
- Operational energy use emission reductions





More intensive use, leaner vehicles and recycling are crucial

Potential GHG savings from material efficiency strategies for cars in G7 (2016-2060)



Most promising strategies reduce materials AND operational emissions through

Reducing the number of vehicles

Making vehicles lighter

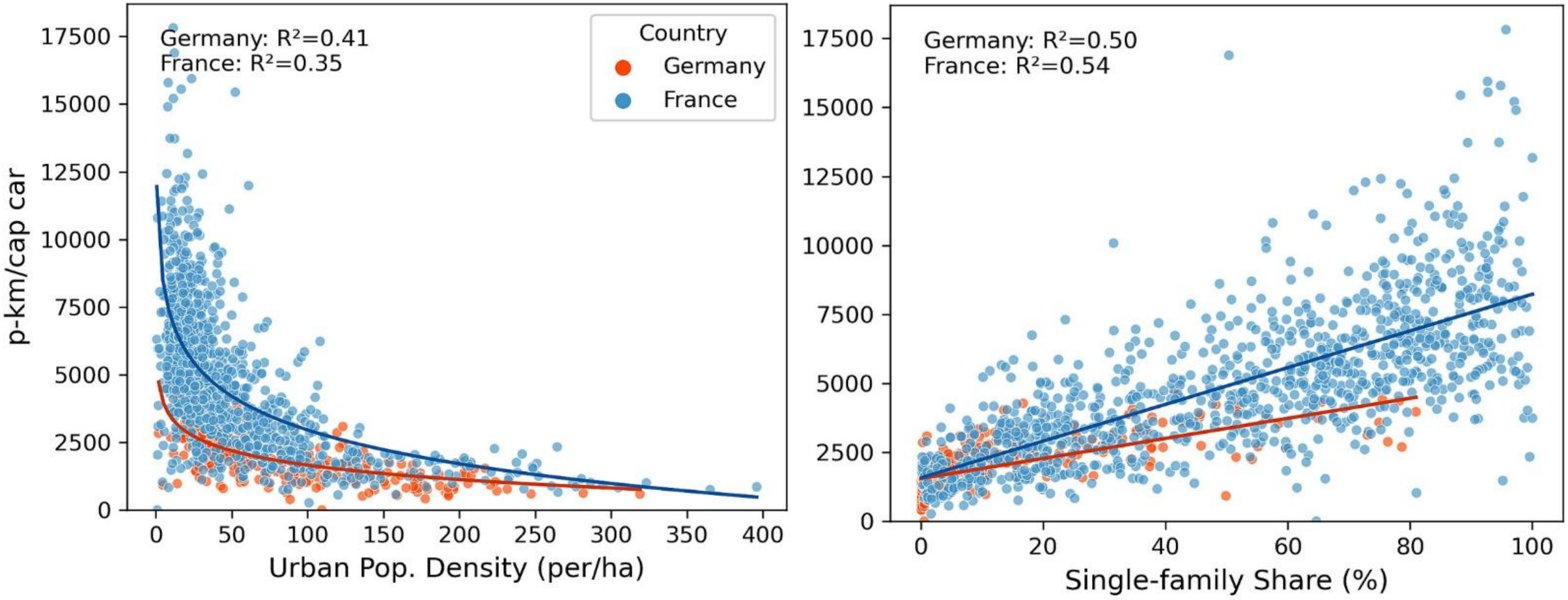
Ca. 25% cumulative savings

**The reduction potentials shown here are for strategy cascades, i.e. implementing one strategy after the other, therefore having synergetic effects.*



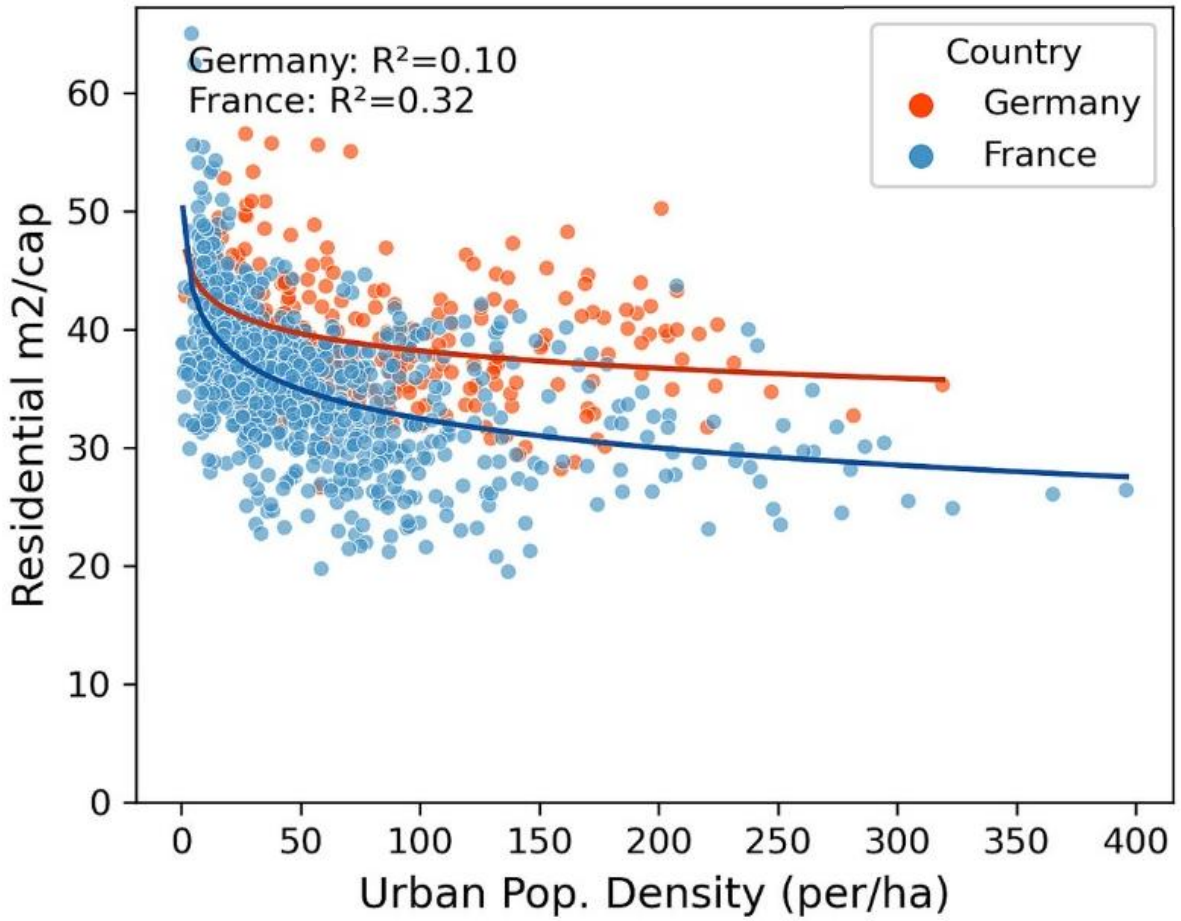
How are transport and housing connected?

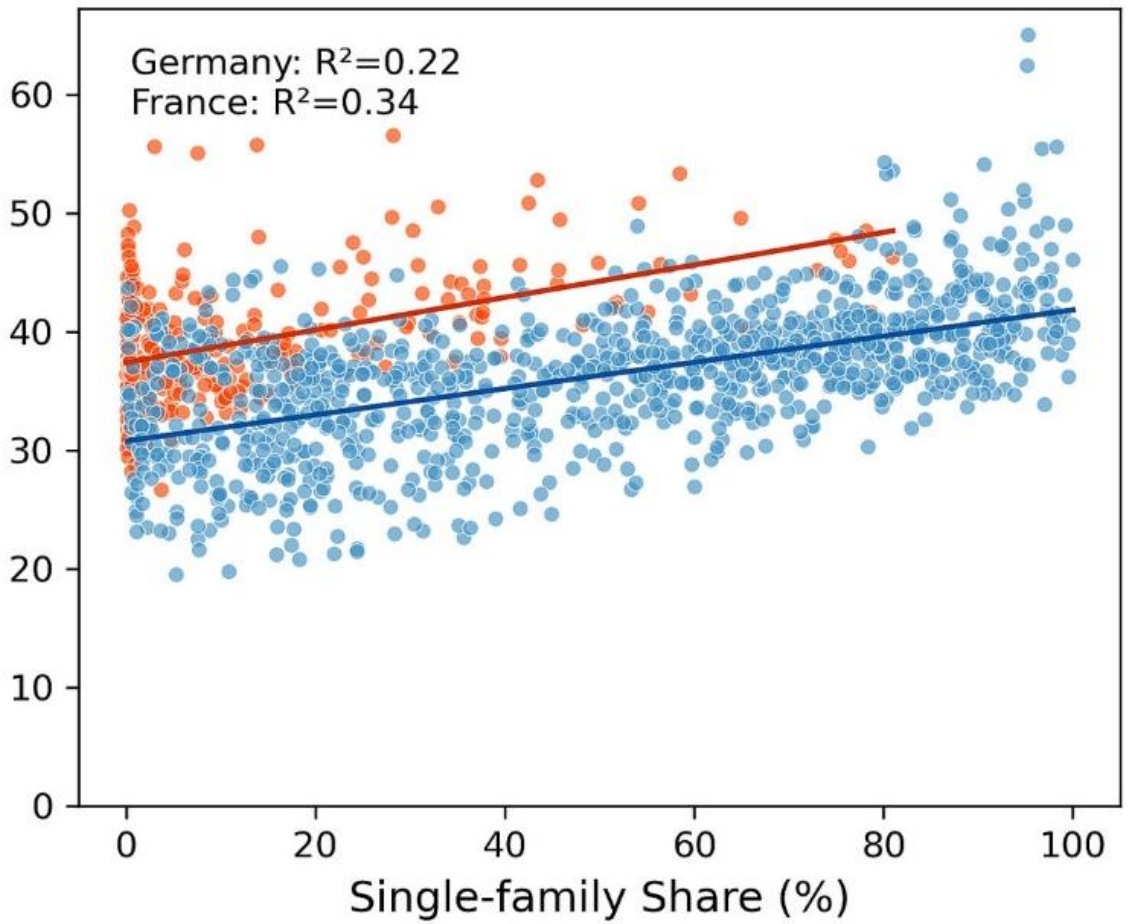
Sparse settlements and single-family residences increase car transport



P. Berrill et al. Quantifying the CO_2 mitigation potential from sustainable urban planning in European cities *Sustainable Consumption and Production* 2026 https://doi.org/10.1016/j.spc.2026.07.006

Sparse settlements and single-family residences lead to large residences





P. Berrill et al. Quantifying the CO_2 mitigation potential from sustainable urban planning in European cities *Sustainable Consumption and Production* 2026 https://doi.org/10.1016/j.spc.2026.07.006

Collective solutions have multiple benefits

Proximity enables sharing

- Transport infrastructure
- Vehicles (rides, cars, public transport)
- Brings anemities closer, better utilized
- Sharing walls (multifamily residences)

Conclusions

- Our consumption is enabled by resource extraction and pollution all over the world
- Material production causes about ¼ of GHG emissions and mostly serves capital formation
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