Energy and Material Efficiency

Dr. Julian Allwood

Low Carbon and Materials Processing Group

Department of Engineering, University of Cambridge

UNIVERSITY OF CAMBRIDGE

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Global Energy/Carbon Analysis

- “Every little helps”

  Old wives’ tale widely quoted in responses to climate change

- “If we all do a little, we get a little”

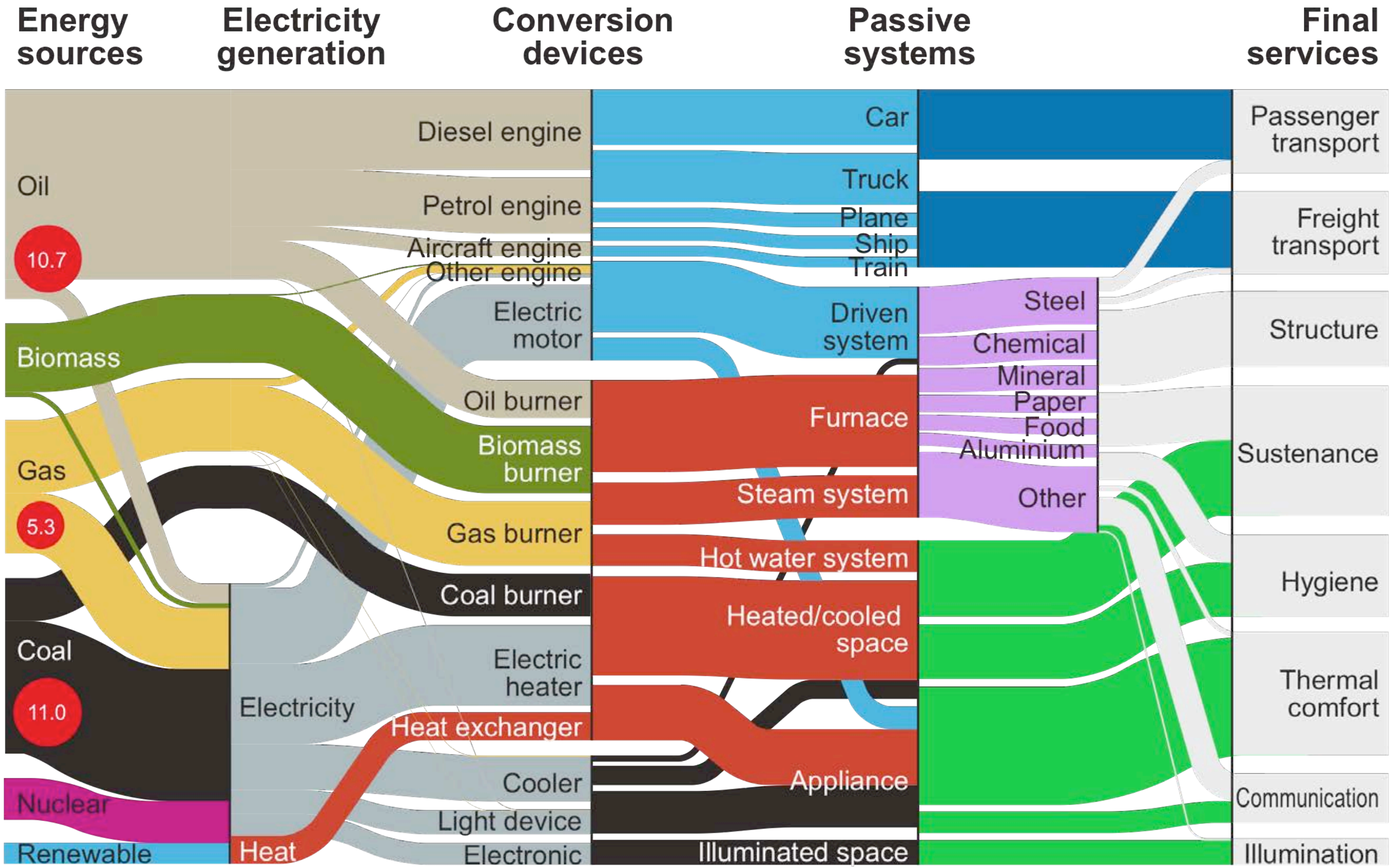
  Professor David Mackay, Chief Scientific Advisor to the Department of Energy and Climate Change

- What would make a big difference to global energy system?

  Climate science broadly accepted, but as yet little concerted action for change by governments

  Initial response to climate concern is almost all on the supply side

  Unclear where to take action – what would make a big (enough) difference



Global energy demand in 2005, total = 475 EJ

Global carbon emissions in 2005, total = 27 Gt CO_2

JM Cullen and JM Allwood
Energy Policy 38 (2010) 75–81

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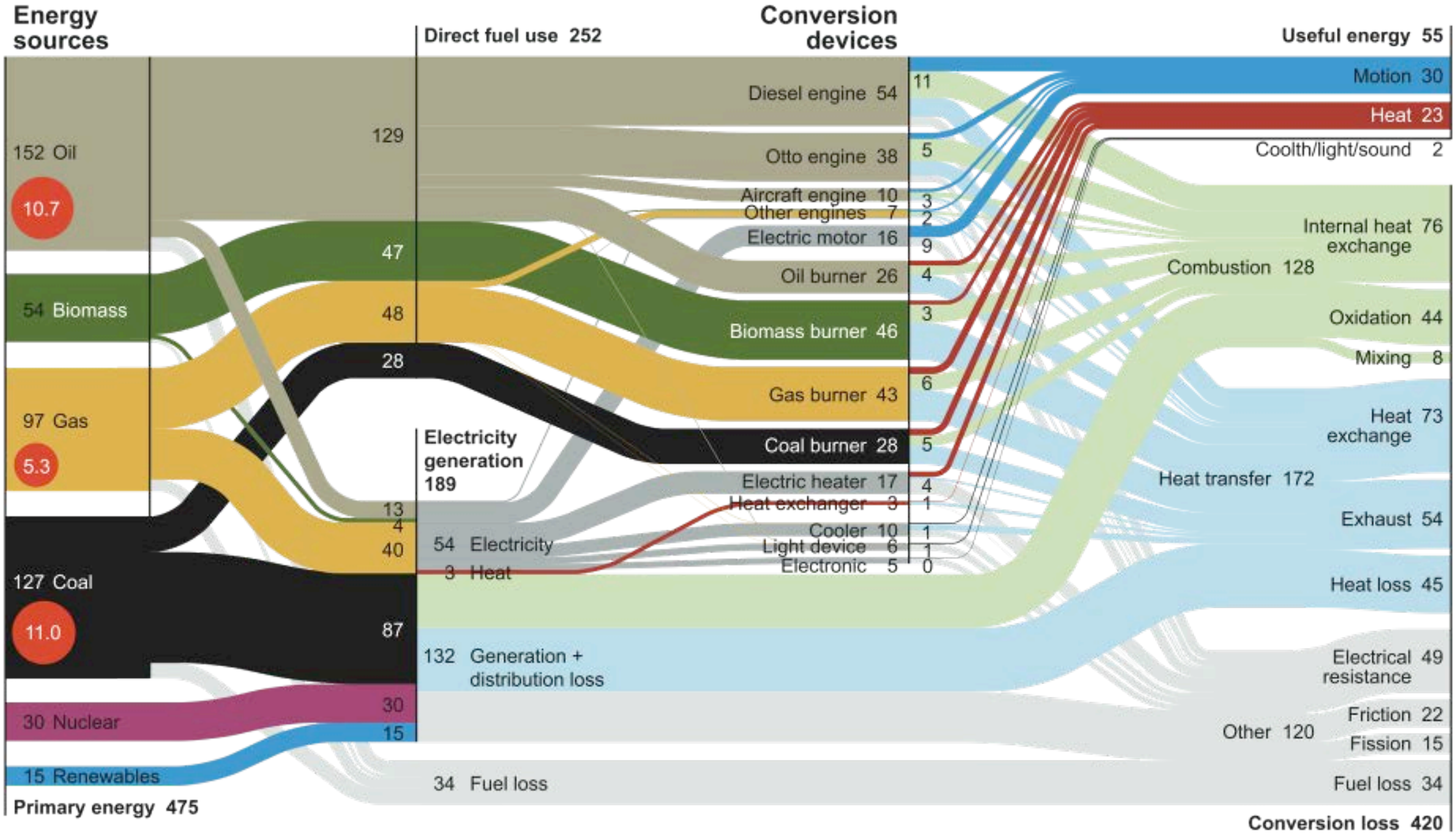
Theoretical efficiency limits in energy conversion devices (11%)



Global energy demand in 2005, total = 475 EJ

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Submitted to *Energy*

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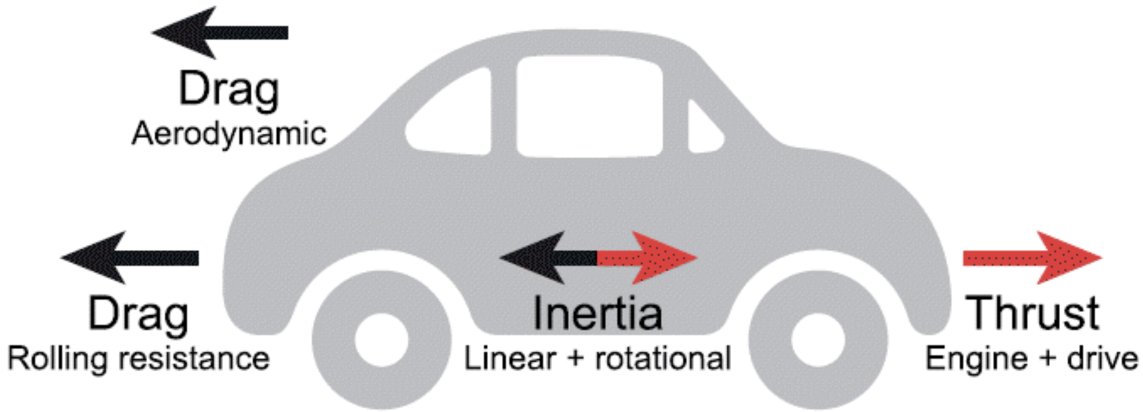
Practical efficiency limits in passive energy systems

Car example



$$F = F_M + F_A + F_I = \mu m g + \frac{1}{2}\rho \nu^2 C_D A_f + m\frac{d\nu}{dt}$$

Mechanical drag
(rolling resistance)
- friction coefficient
- mass of vehicle

Aerodynamic drag
- drag coefficient
- frontal area of vehicle

Practical efficiency limits in passive energy systems

Car example

Weighted average of current cars

Practical minimum

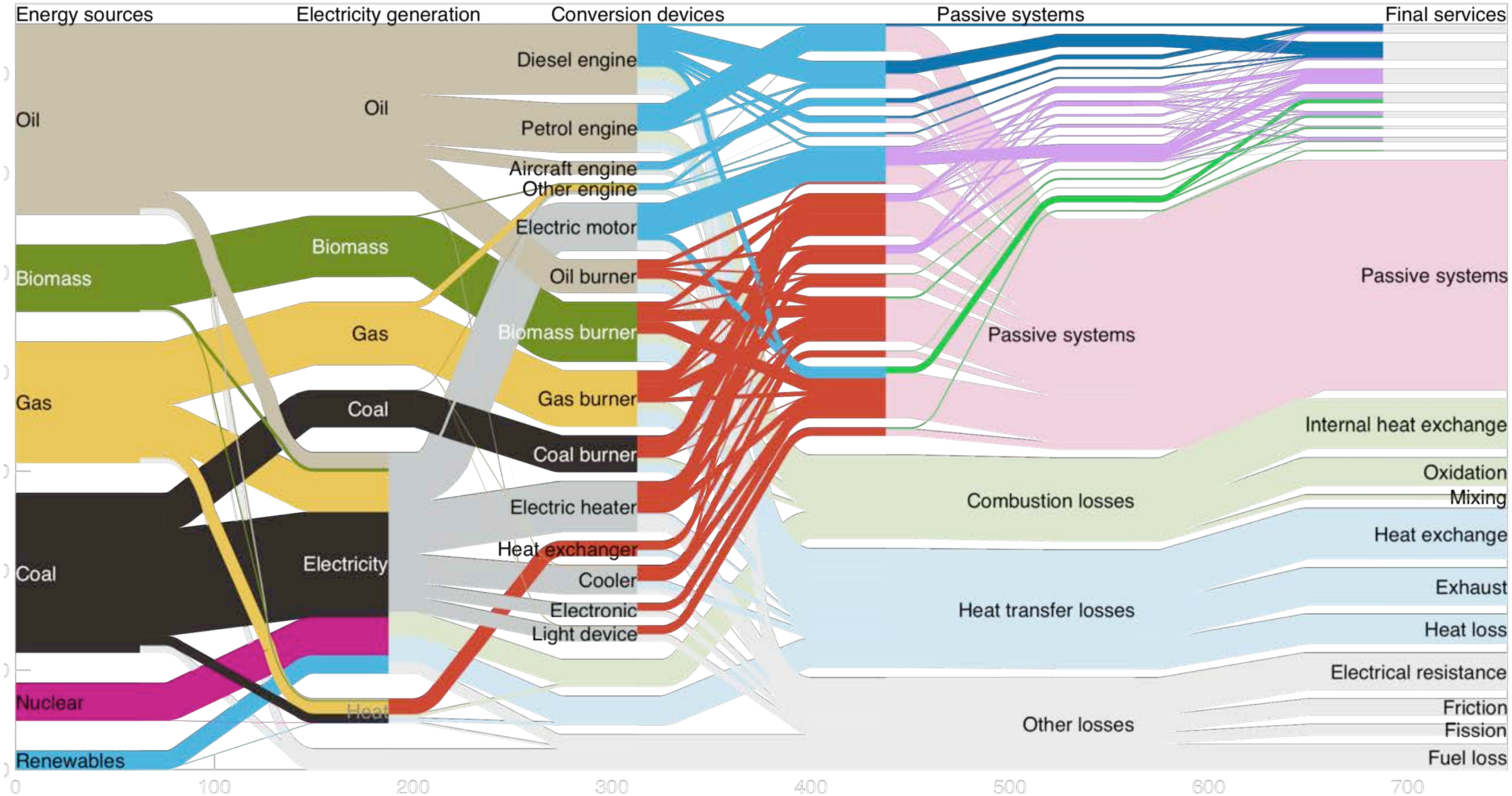
91% potential for saving energy

Practical savings available in cars

Design[1]	m	ν	μ	C_D	A	f_i	F_M	F_A	F_I	F
	t	m/s			m^2	%	N	N	N	N
Gasoline										
<1.4l	1.0	19	0.015	0.40	1.9	36	147	163	130	440
1.4–2.0l	1.2	20	0.015	0.40	2.0	28	177	201	155	533
>2.0l	1.4	21	0.015	0.40	2.1	6	206	232	178	616
LDV[2]	2.1	17	0.015	0.50	2.2	3	309	199	223	731
Diesel										
<2.0l	1.3	19	0.015	0.40	2.0	11	191	174	156	521
>20.0l	1.5	19	0.015	0.40	2.1	7	221	193	174	588
LDV[2]	2.1	16	0.015	0.50	2.2	8	309	165	219	693
Current[3]	1.3	19	0.015	0.41	2.0	100	188	183	157	528
Practical	0.3	19	0.001	0.10	1.5	100	3	33	13	49
							Practical energy savings available **91%**			

Notes: [1] by fuel type and engine size in litres, [2] LDV = light duty vehicle, [3] weighted average, by the distribution of total distance travelled (f_i). m = mass, ν = average velocity, μ = friction coefficient, C_D = drag coefficient, A_f = frontal area, F = force, with subscripts $_M$ mechanical, $_A$ aerodynamic and $_I$ inertia

Practical losses in the global energy system (88%)



Global Energy Efficiency

- What have we learnt?

  Our Sankey Diagram is the first breakdown of global energy transformation by technology (rather than economic sector) – so gives a nice basis for considering technical options

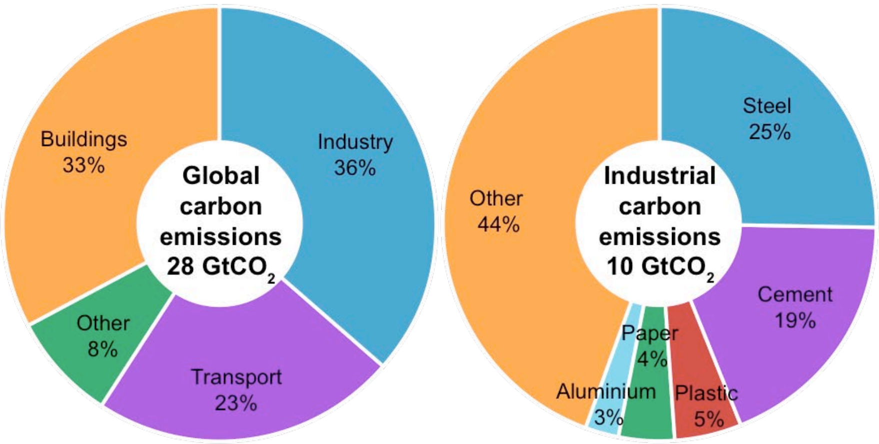
  It’s very unlikely that a low carbon future will be created on the supply-side

  Tremendous demand side efficiency options exist in buildings and transport (lightweight road-vehicles and passive buildings)

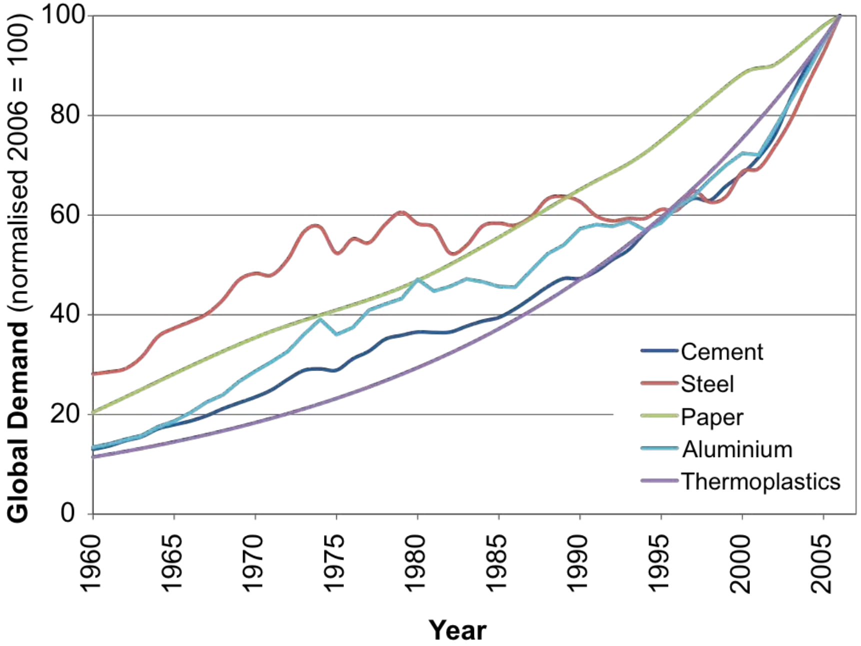
  But what about industry.....?

Energy and emissions in industry

Emissions dominated by 5 materials…



…and demand likely to double by 2050



- What would make a big enough difference?

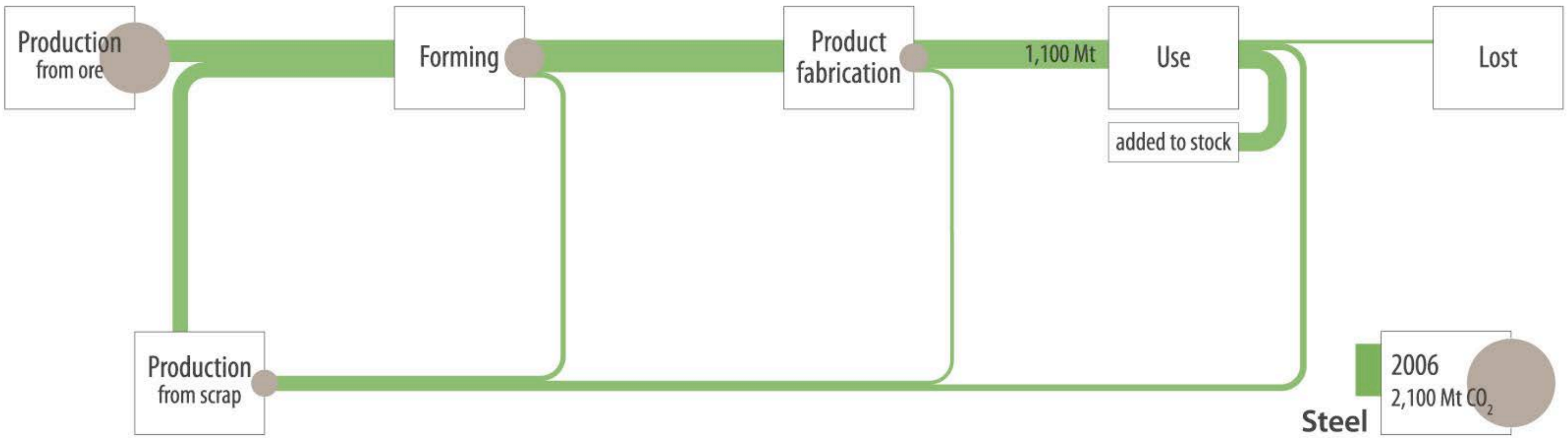
Product based analysis (LCA, EU policy) cannot answer this question

Total Material Requirements analysis is not specific enough

Instead, we can take a top-down global view for these five materials….

The scope of required change in industry

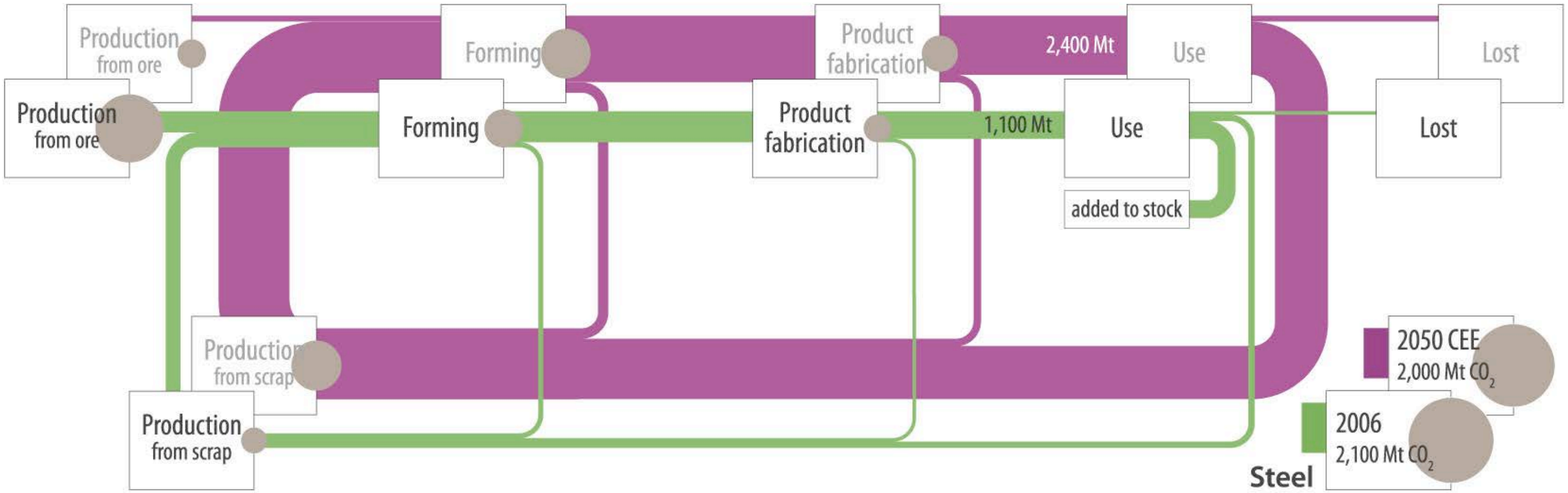
Current situation



Data from Yale “Stocks and Flows” project scaled by IISI global demand data.

The scope of required change in industry

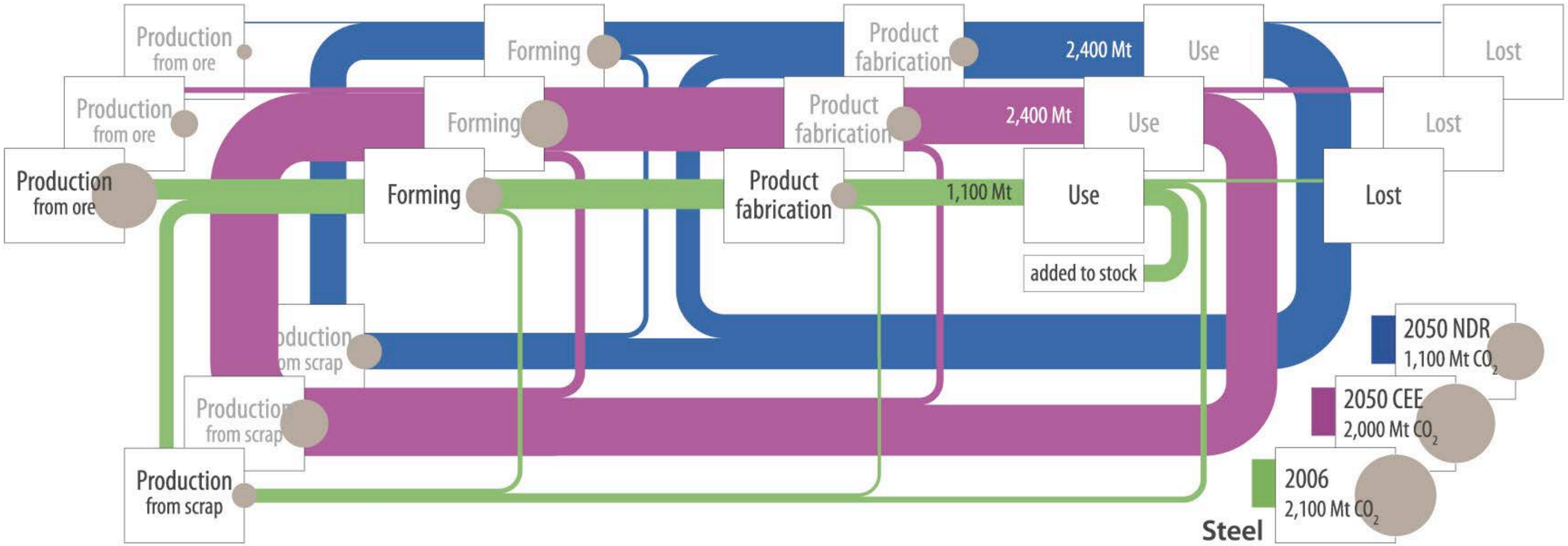
Doubling of demand with perfect implementation of all known gains in efficiency (40% cut in primary emissions due to technology gains plus 20% de-carbonisation of all energy



Data from Yale "Stocks and Flows" project scaled by IISI global demand data.

The scope of required change in industry

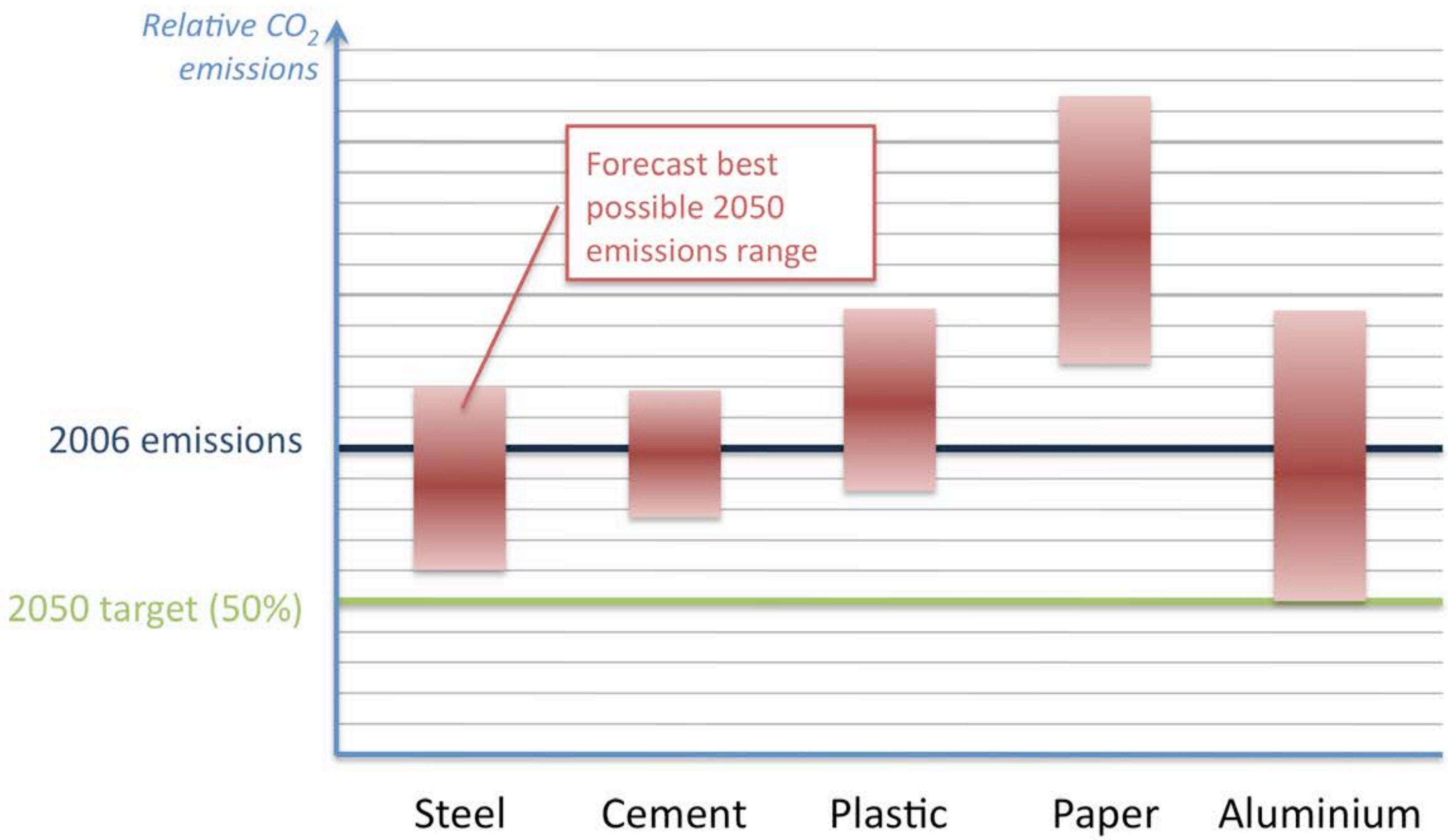
Doubling of demand with forecasted gains in efficiency, and non-destructive recycling



Energy Efficiency will not have enough impact in Industry. However there are additional options within Material Efficiency.

Data from Yale "Stocks and Flows" project scaled by IISI global demand data.

How far can energy efficiency go within existing industry?



- Even with the strongest possible assumptions, we cannot hit carbon emissions targets by energy/process efficiency within the existing system

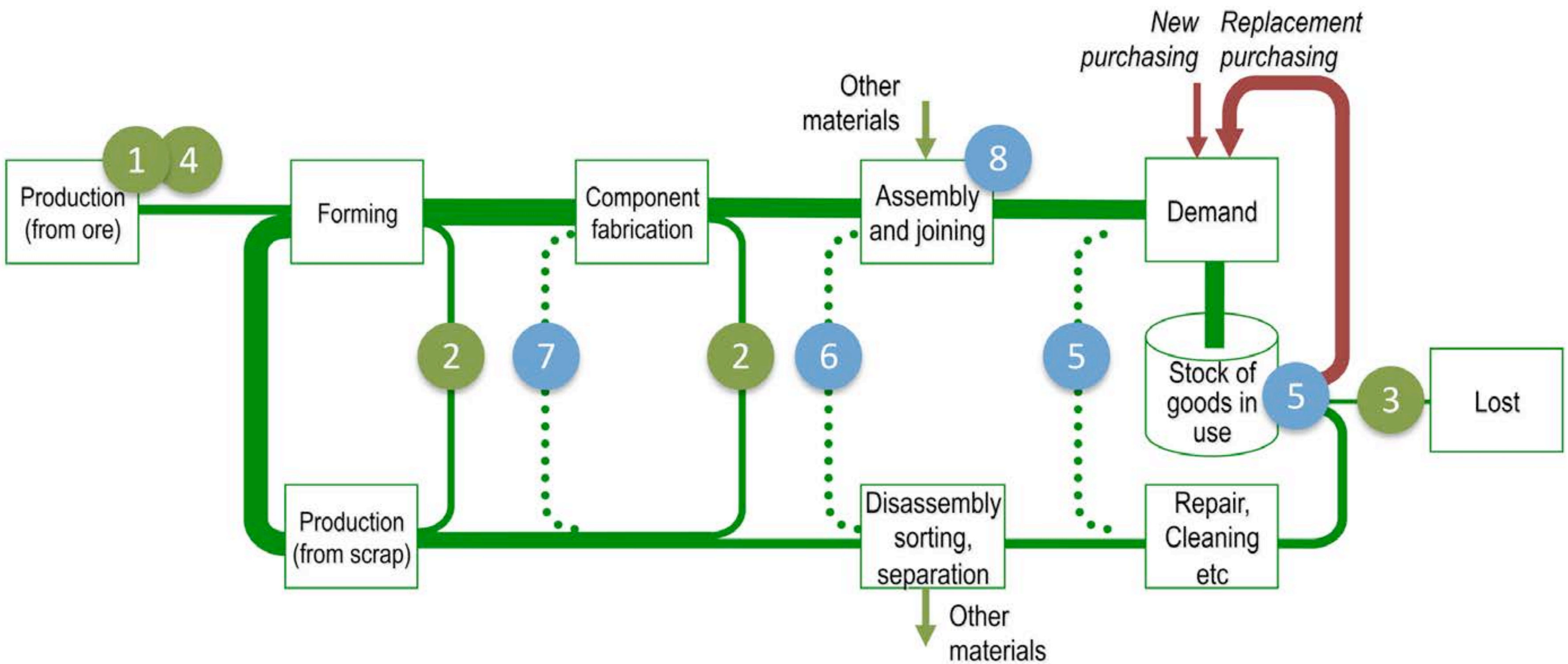
Options to halve emissions while demand doubles?

Energy and Carbon Efficiency strategies:

1. Energy efficiency
2. Yield improvement
3. More recycling
4. Carbon Capture – process or energy

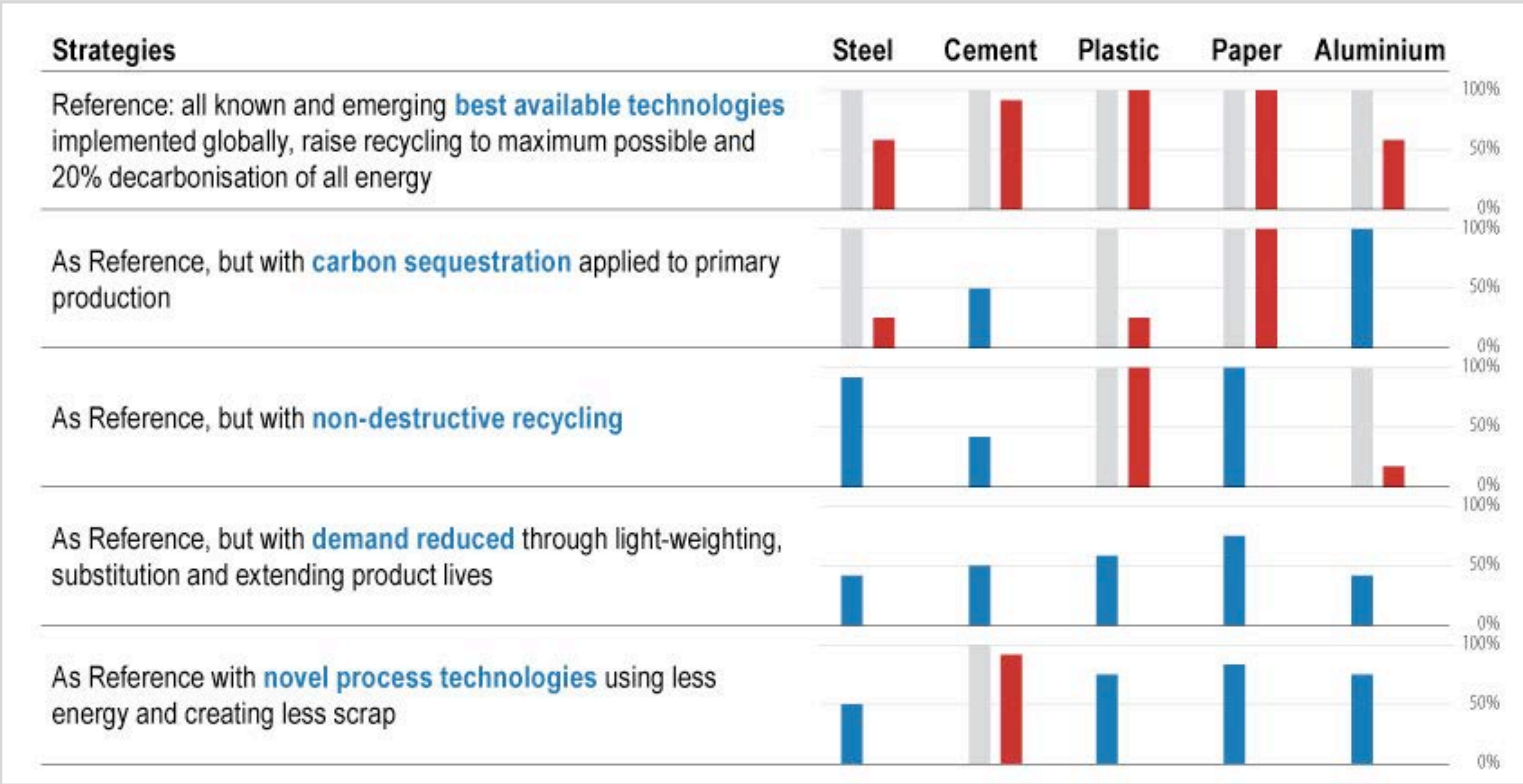
Material Efficiency strategies:

5. Longer life, more use, repair and re-use
6. Product upgrade
7. Component re-use
8. Less metal, same service

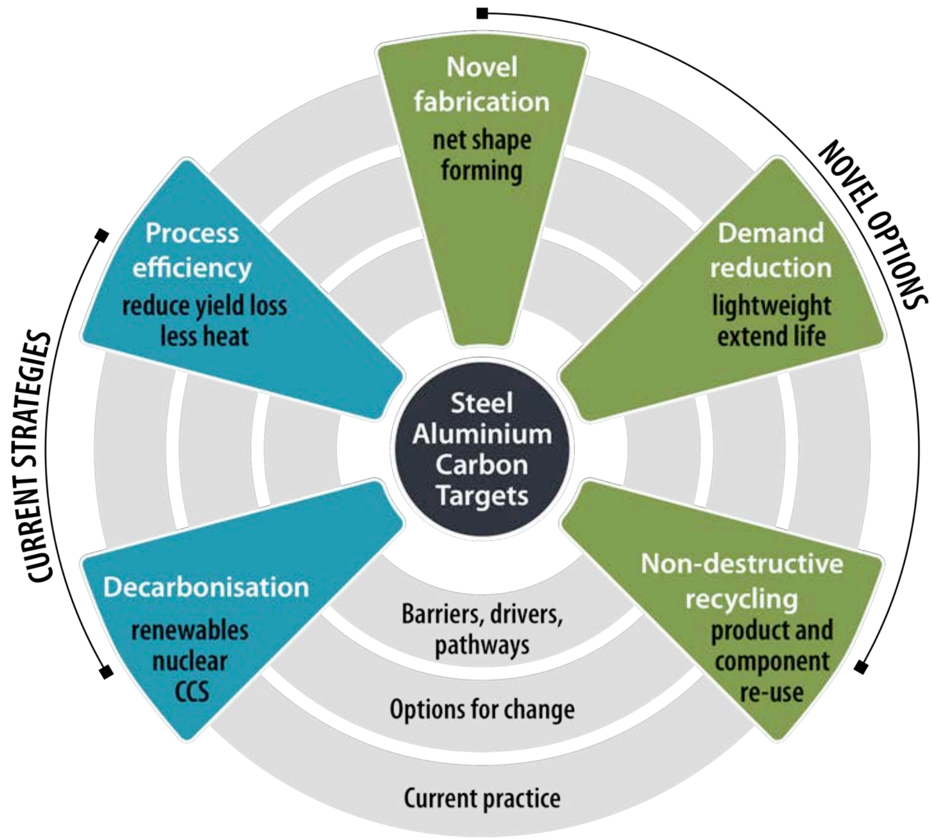


What strategies might give enough emissions cuts?

... and how extensively must each strategy be implemented to reach the 2050 target?



WellMet2050 themes and partners



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Summary

- "If we want to make a big difference, we need to make a big change"
  - It's unlikely we will find a sufficient solution on the supply slide
  - Energy efficiency in transport and buildings has enormous scope
  - In industry, energy efficiency has limited further potential
- Material Efficiency
  - Is the last option before demand constraint
  - Has great technical potential - particularly in re-use of large parts
  - Is currently 'inconvenient' - but we have no choice but to make it happen
- What do we need to do now?
  - We have enough analysis.
  - We need to create big scale demonstrators that others can copy

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