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UTRECHT SUSTAINABILITY INSTITUTE

KIVI Engineering Society

# Verduurzaming van de industrie

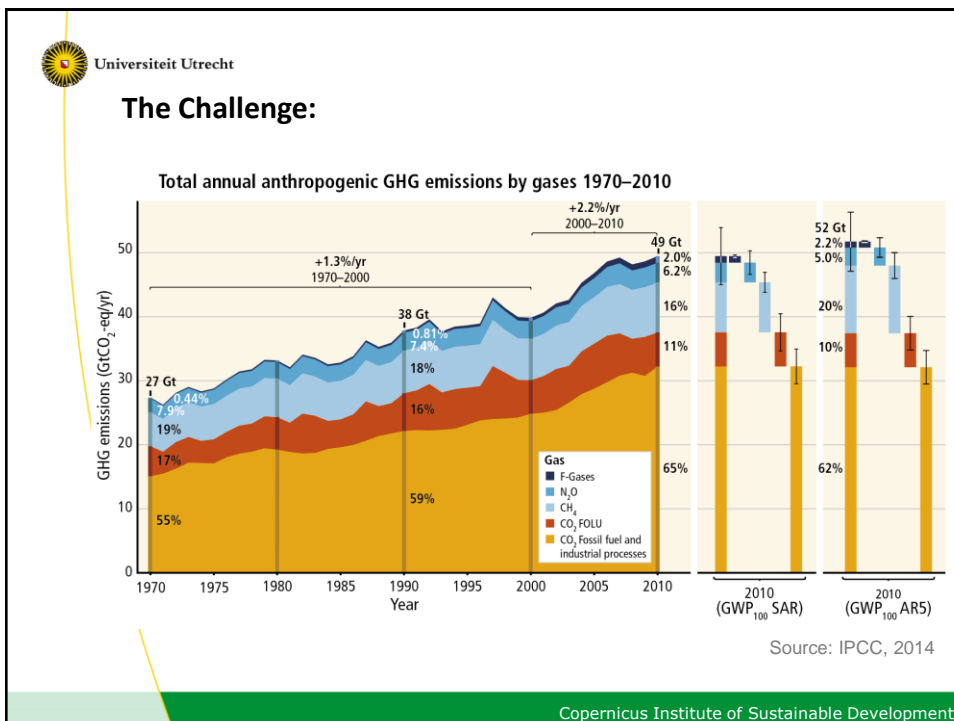
Ernst Worrell  
Universiteit Utrecht

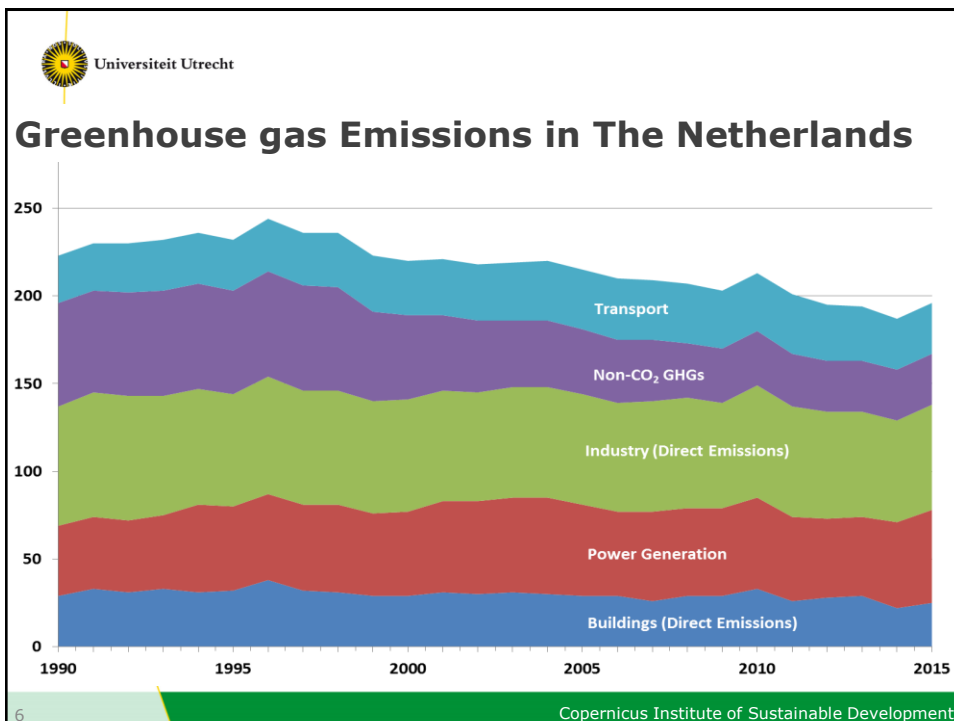
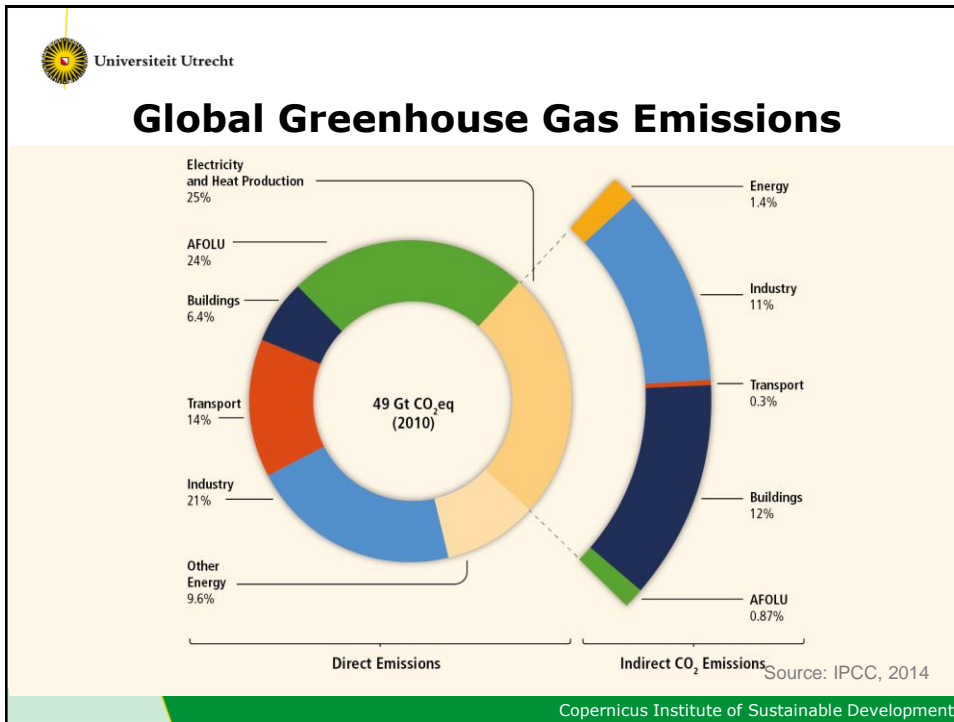


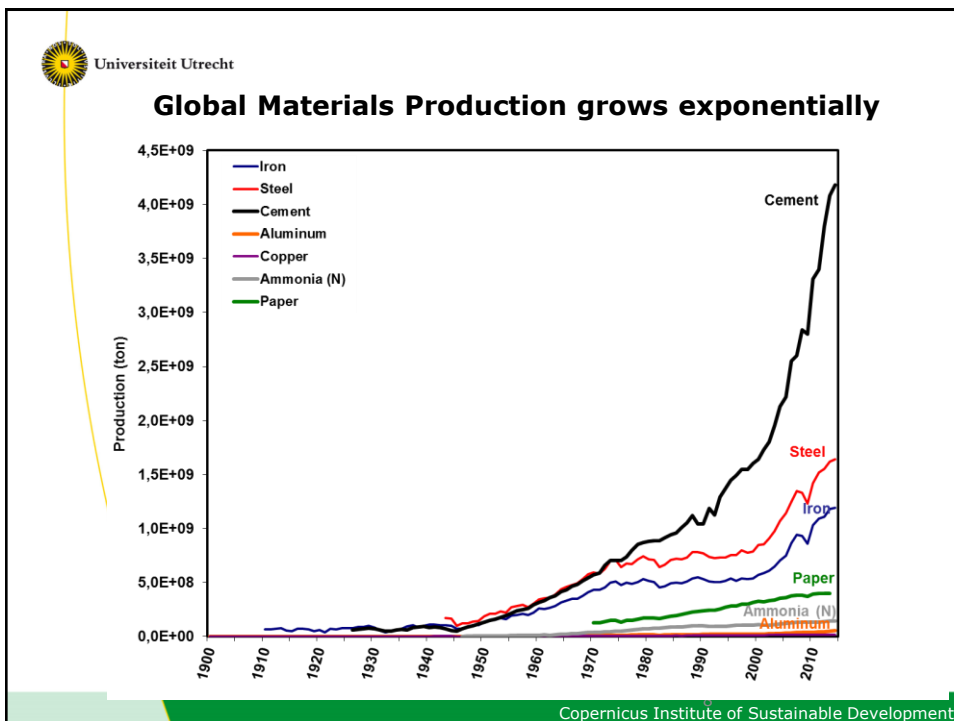
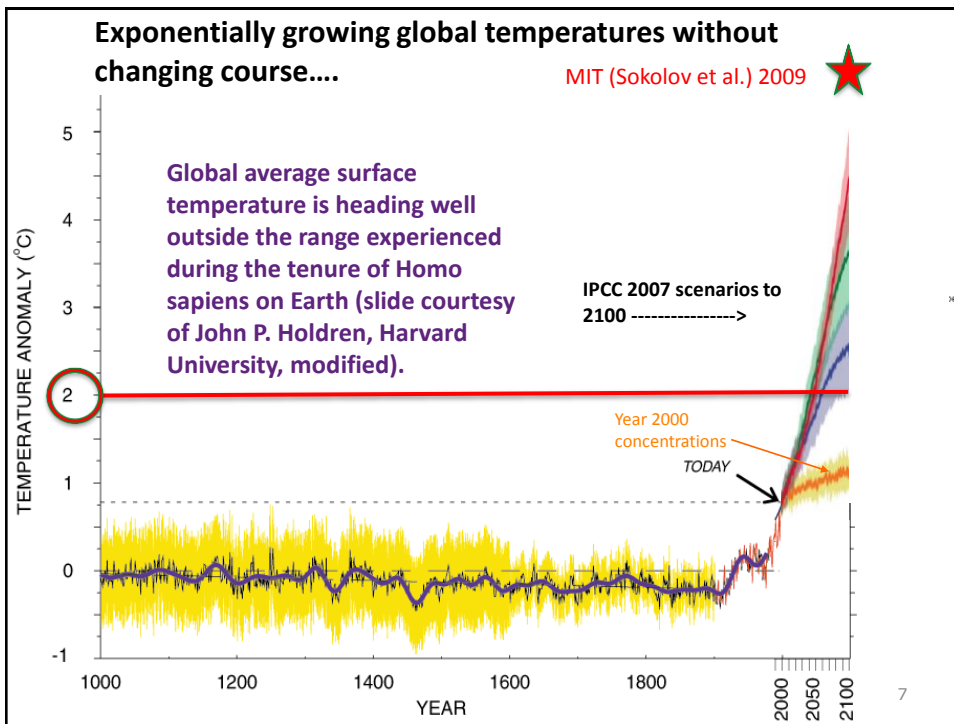
Anyone who believes that exponential growth can go on forever in a finite world is either a madman or an economist.

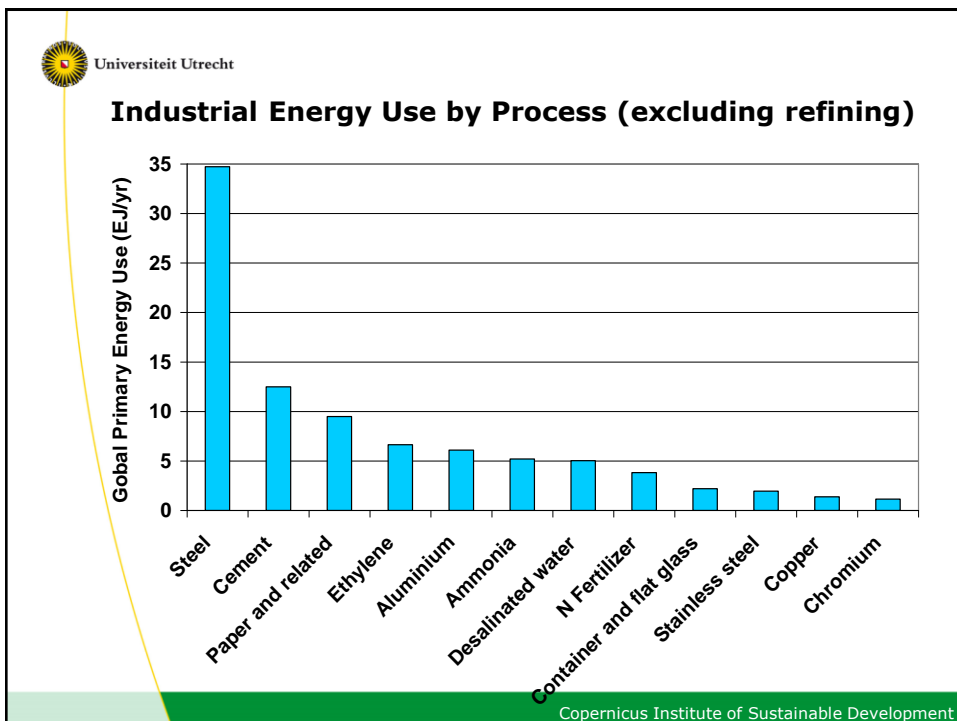
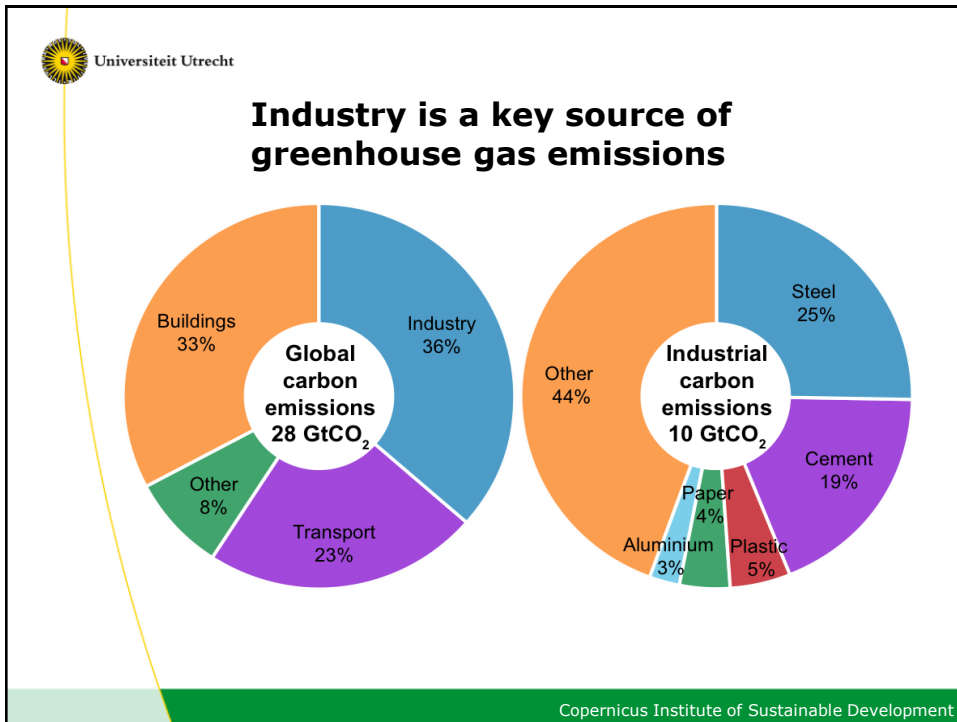
Kenneth E. Boulding

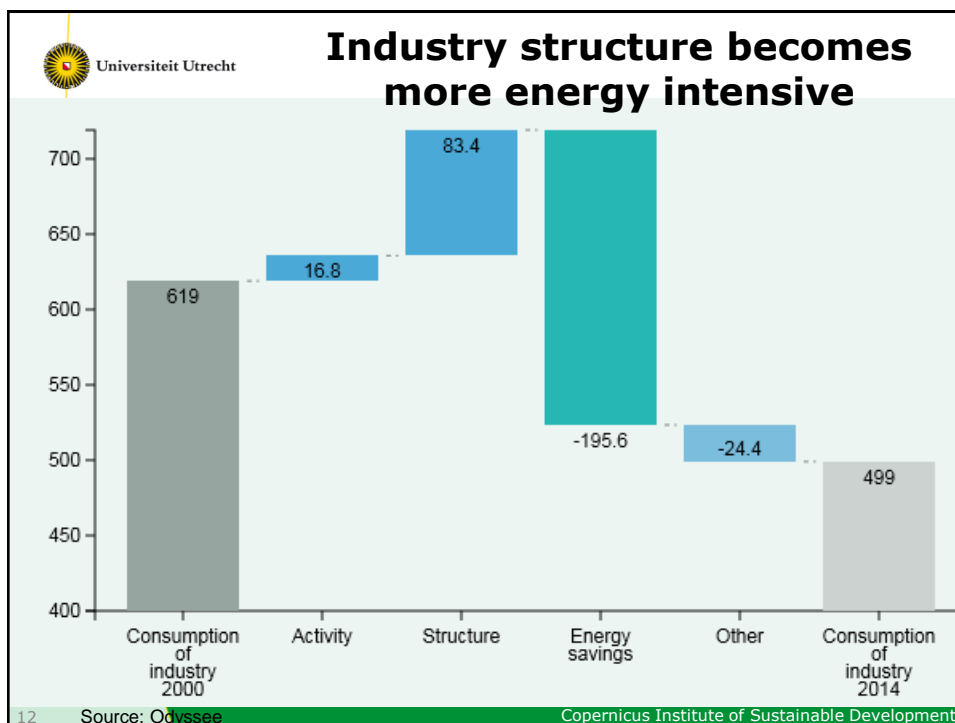
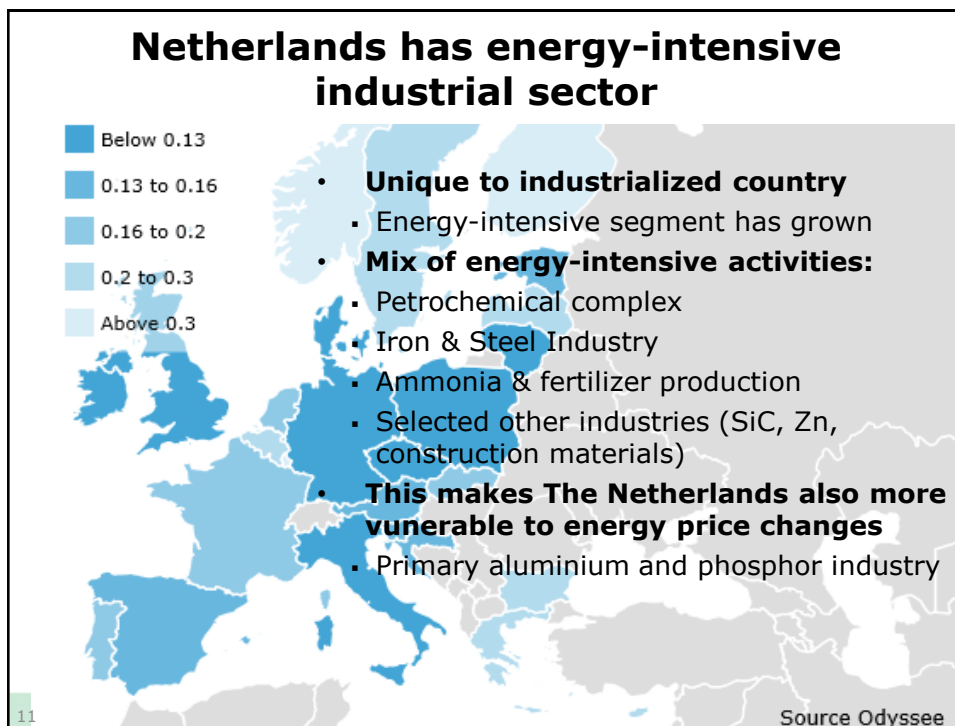
(1910 -1993)



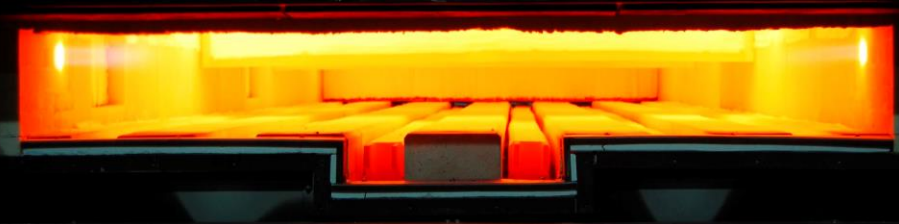








## Industry Emissions Hard to Reduce



Selected industrial processes currently depend on fossil fuels:

- High-temperature processes
- Need for carbon as reactant
- Interrelated with feedstock

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## Opportunities for Change

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## Options along the supply chain

- **Energy efficiency**
  - On-site
  - In the supply chain
  - Industrial symbiosis
- **Material efficiency**
  - Circular economy
  - Material demand reduction
- **Fuel mix change**
  - Low-carbon fuels (incl. biofuels)
  - Electricity
- **Carbon Capture Storage/Utilization**

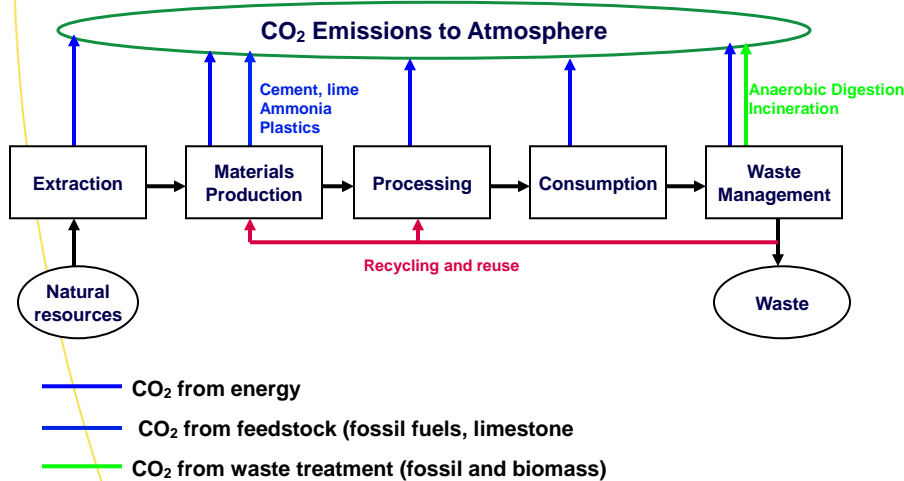
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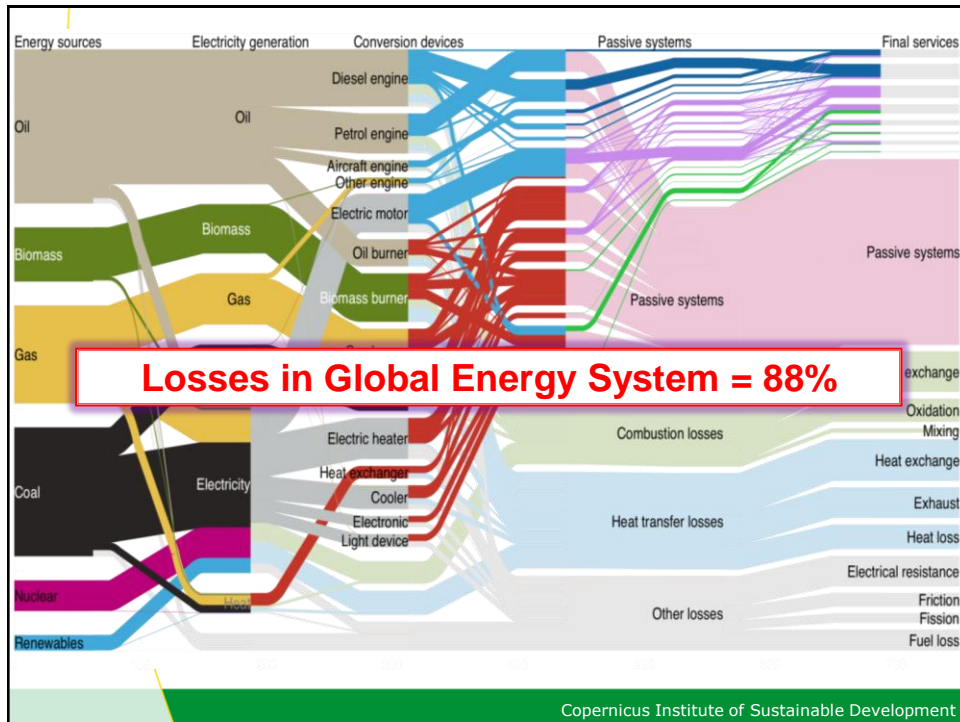
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## Reducing Emissions along the Supply Chain



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### Understanding Energy Efficiency Improvement Potentials

<i>SEC in GJ/t product</i>	Current	Present best	Prospective technology	Theoretical minimum SEC
Primary steel	19-40	19	13	7
Secondary steel	6-12	6	4	0
Ammonia	33-47	33	29	19
Ethylene	14-22	14	11	5
Cement	3-6	3	2	1

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## Industrial Energy Efficiency Opportunities

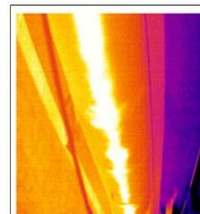
### Two ways to break down opportunities

#### Cross-Cutting

- Steam systems 10-20%
- Cooling/Refrigeration 20-40%
- Motor Systems ~ 30%

#### Sector-Specific processes in:

- Iron & Steel
- Cement
- Petroleum refining
- Chemicals
- Pulp & Paper



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## Motor Systems

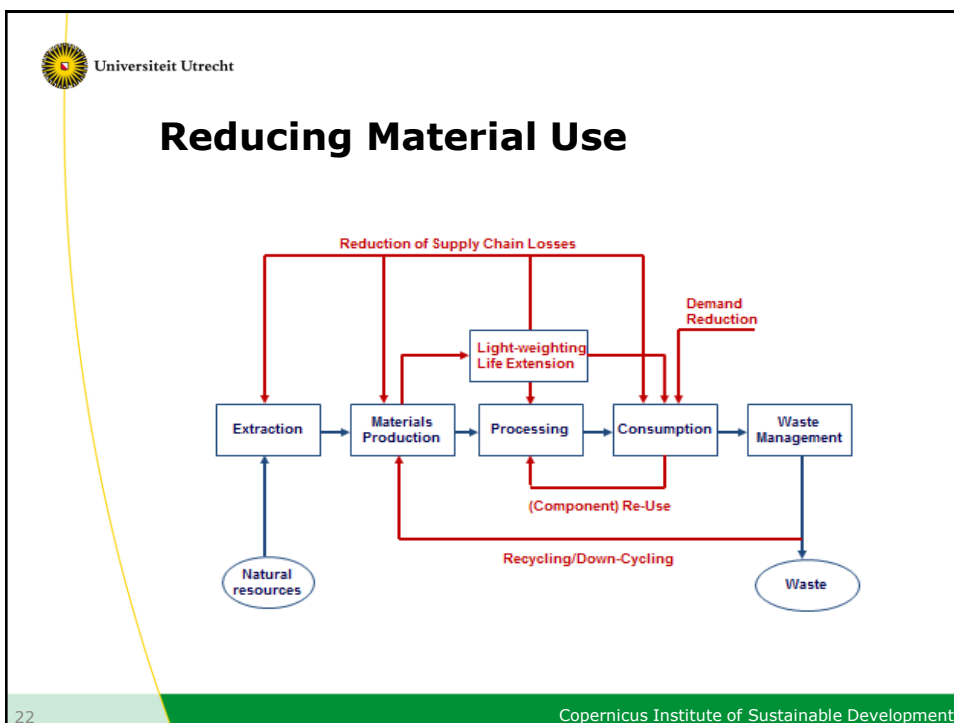
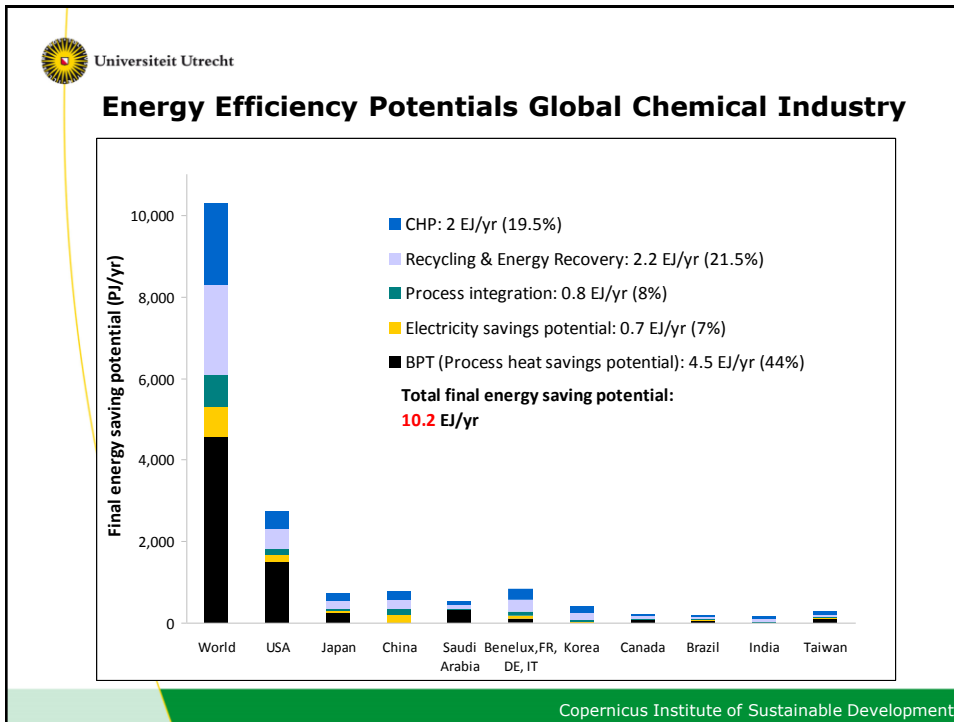
**Motor systems use 2/3 of electricity in industry**

**Motor systems are largest electricity user in almost every industrial sector**

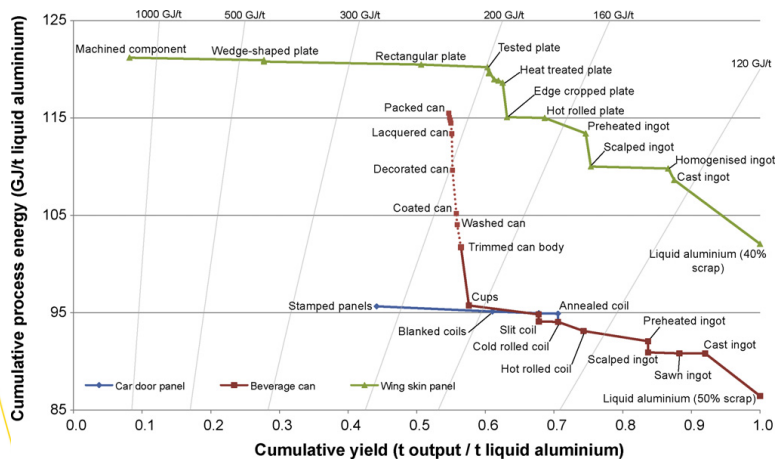
**Large potential for energy-efficiency improvement**

**Studies in US, Europe and China show saving potentials in motor systems up to 30-40%**

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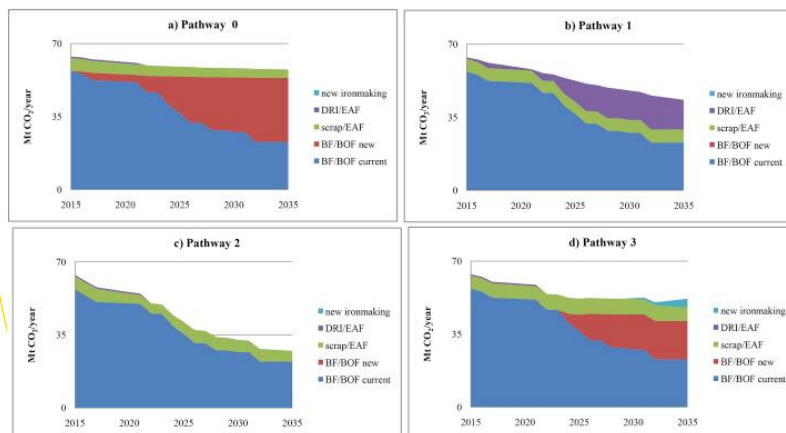


## Follow the material: Understand the Losses



Source: Milford et al., 2011

## Recycling Reduces Emissions (Case study of German Steel Industry)

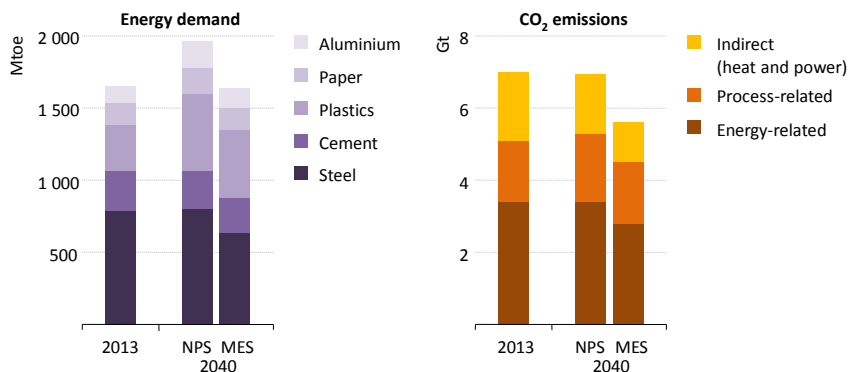


Source: Arens et al., in press

## Adding up: Material energy & CO<sub>2</sub> savings

World  
Outlook  
Energy  
2015

### Energy demand & CO<sub>2</sub> emissions from the production of selected energy-intensive materials in the New Policies Scenario & Material Efficiency Scenario



*Material efficiency can keep energy demand from energy-intensive sectors stable & cut energy- & process-related CO<sub>2</sub> emissions by 1.4 Gt*

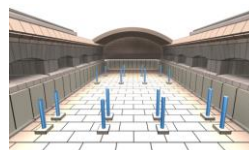
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## Fuel Shifting in Industry

- **Shift to low-carbon fuels**
  - Natural gas
  - Bio-energy
- **Electrification**
  - Furnaces
  - Boilers
  - Electrolytic processes
- **Renewable Energy**





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Dank voor uw aandacht!



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