Jan.Harmsen: shell Groningen 97 link between industry and academia

What is the status SD and industry, what is the future, what problem remains?

Sustainability and Industrial Processes
TARDIS 2008

Prof. Jan Harmsen

- **Sustainable Development and Industry**
- **Global Carbon and Industry**
- **Industrial processes improvements**
- **Problem statement**

Brundlandt 87 Elkington WBCSD 97 Triple P UN J burg 2002 Prosperity

Suffient Concensus robust

Sustainable Development Concensus

Provide in Needs with Next Generations Same Opportunity

Scales: World, Long Term

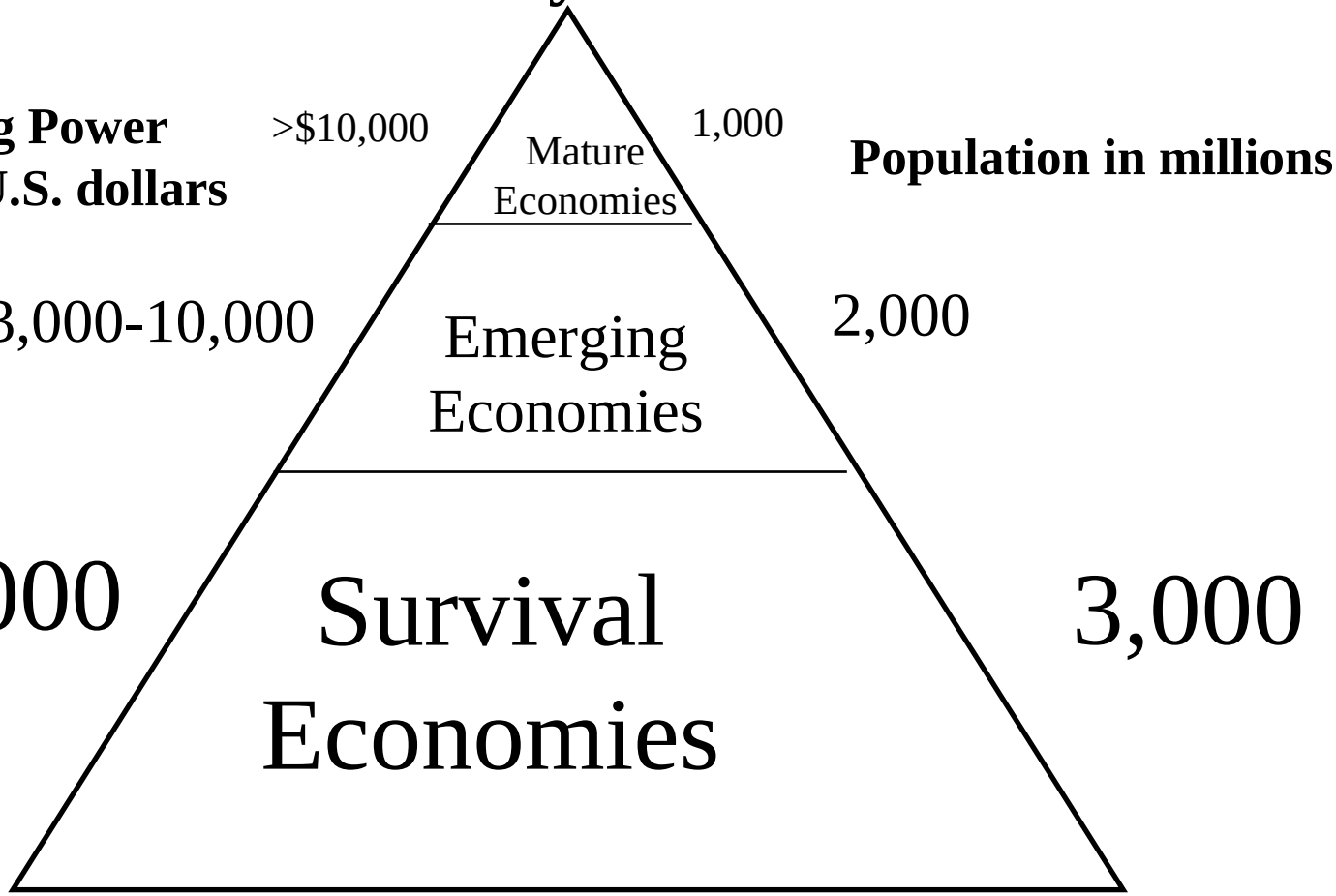
Goal: Prosperity: Enhance Human Welfare

Constraints: Planet: Precaution Principle

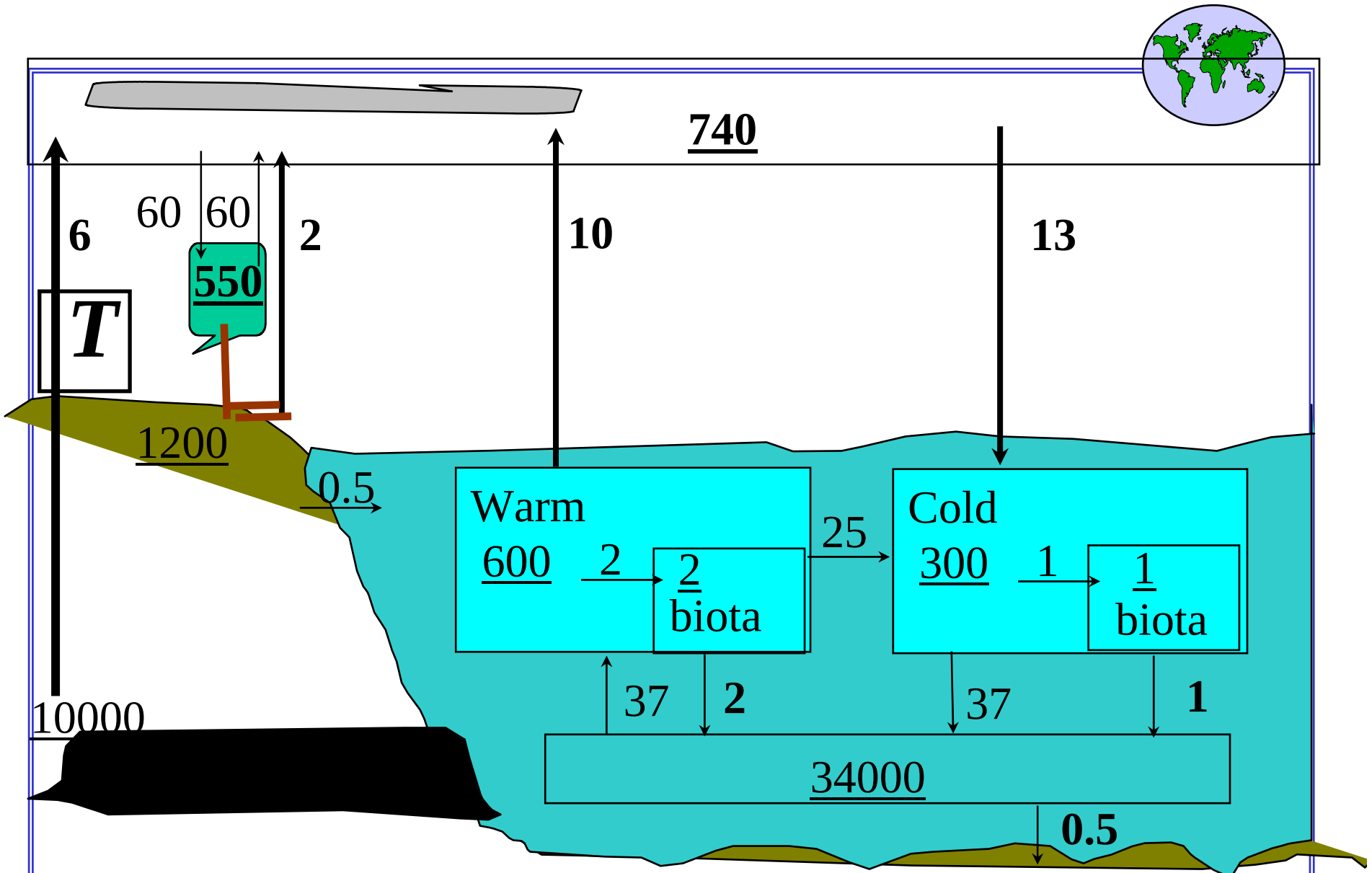
Triple P Profit: Scarce Resources, External cost Internalise

People: Accepted

Economic Sustainability Lens: Global Pyramid

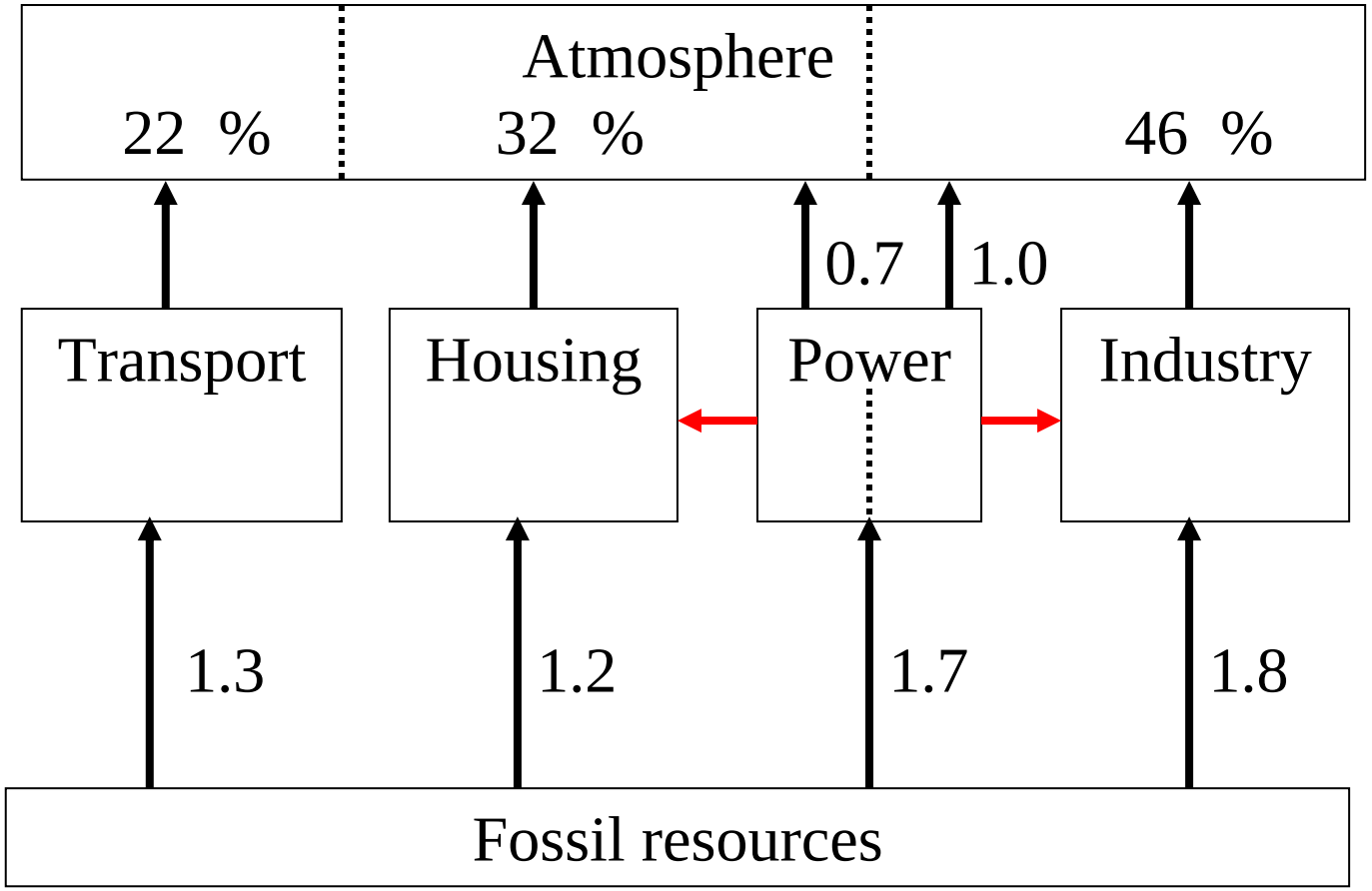


S. Hart HBR



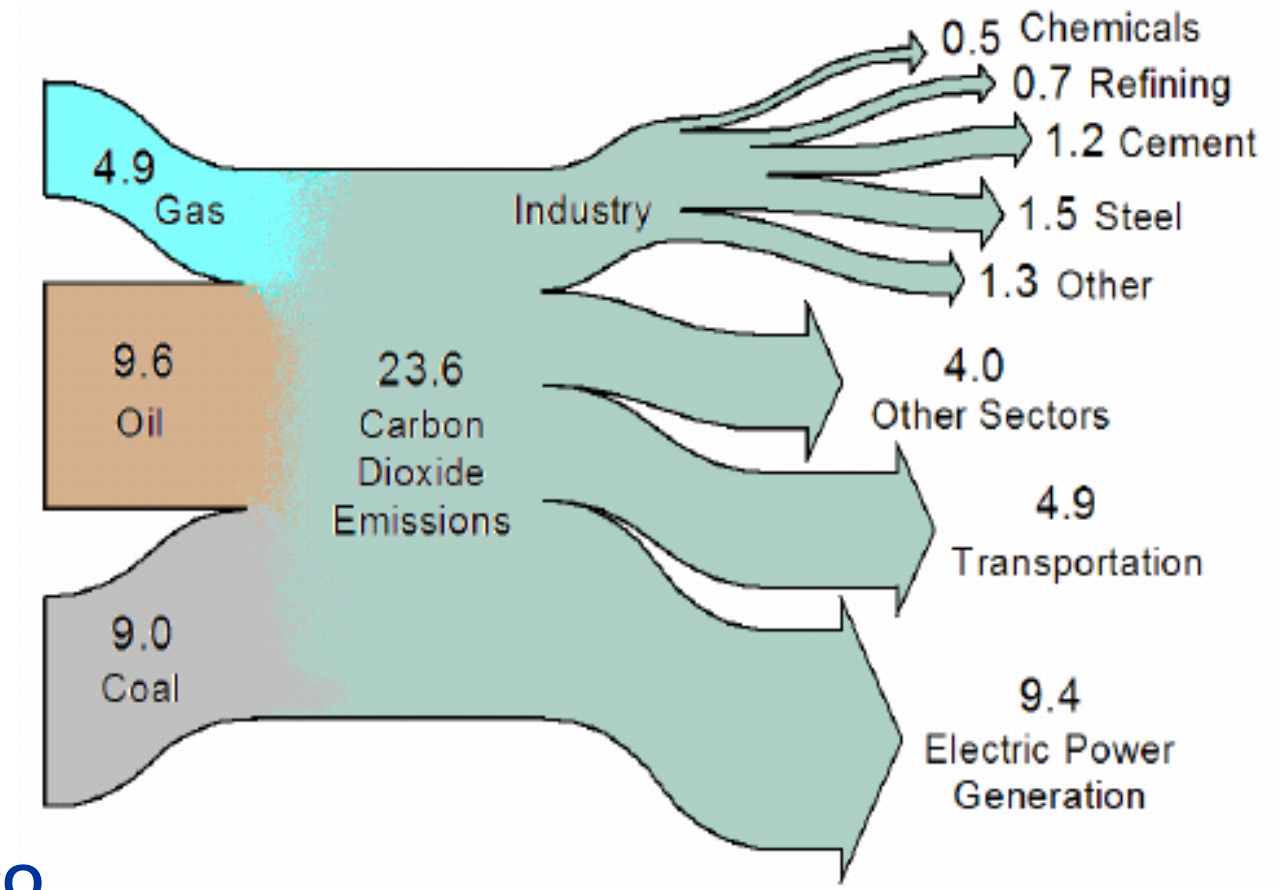
Mondial Carbonflows (Gton/y) en **reservoirs** (Gton) : NASA

Global Antropogenic Carbon flow



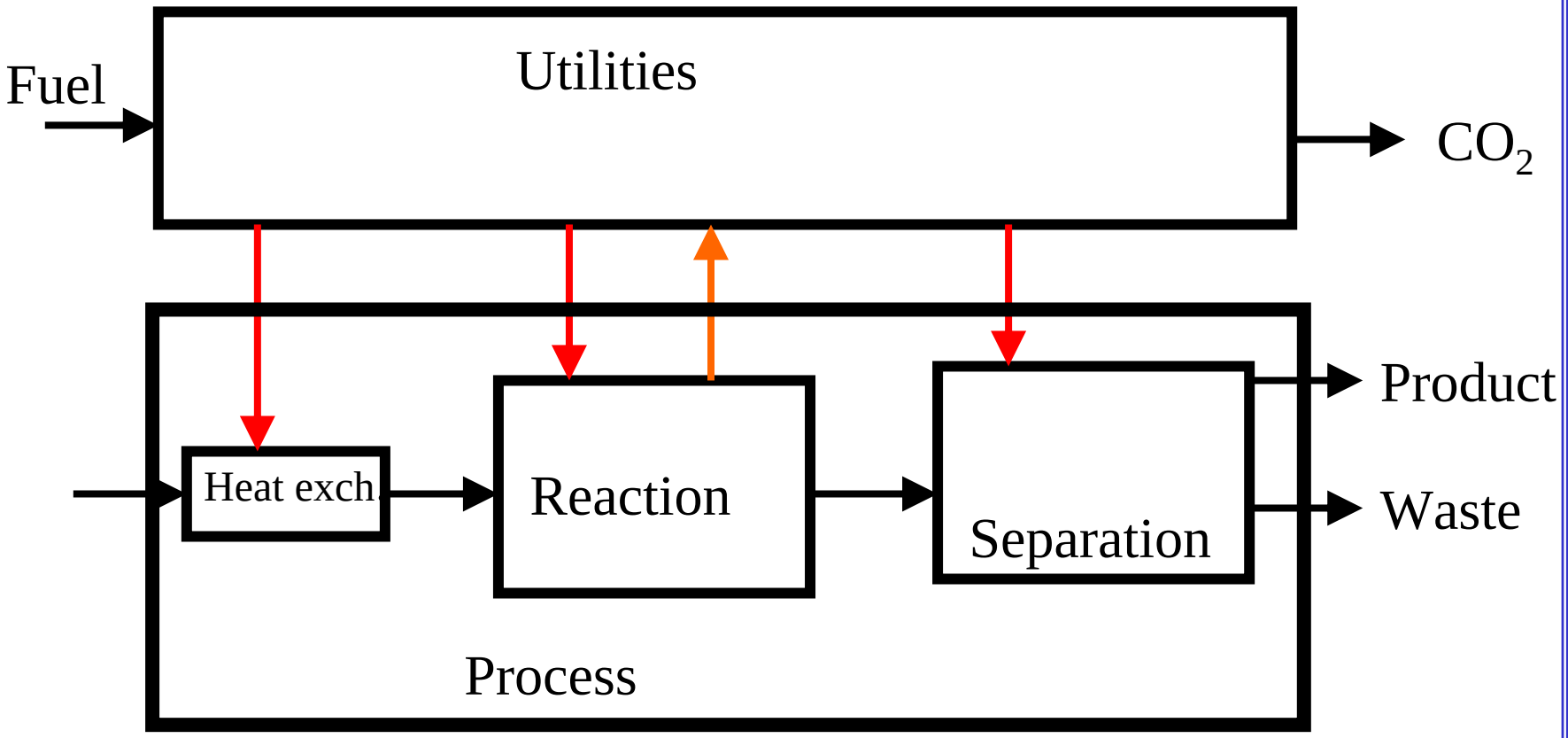
Big ones primary refining, housing, transport and Power

Global CO_2 emissions (2004)



C = 12/44 CO_2

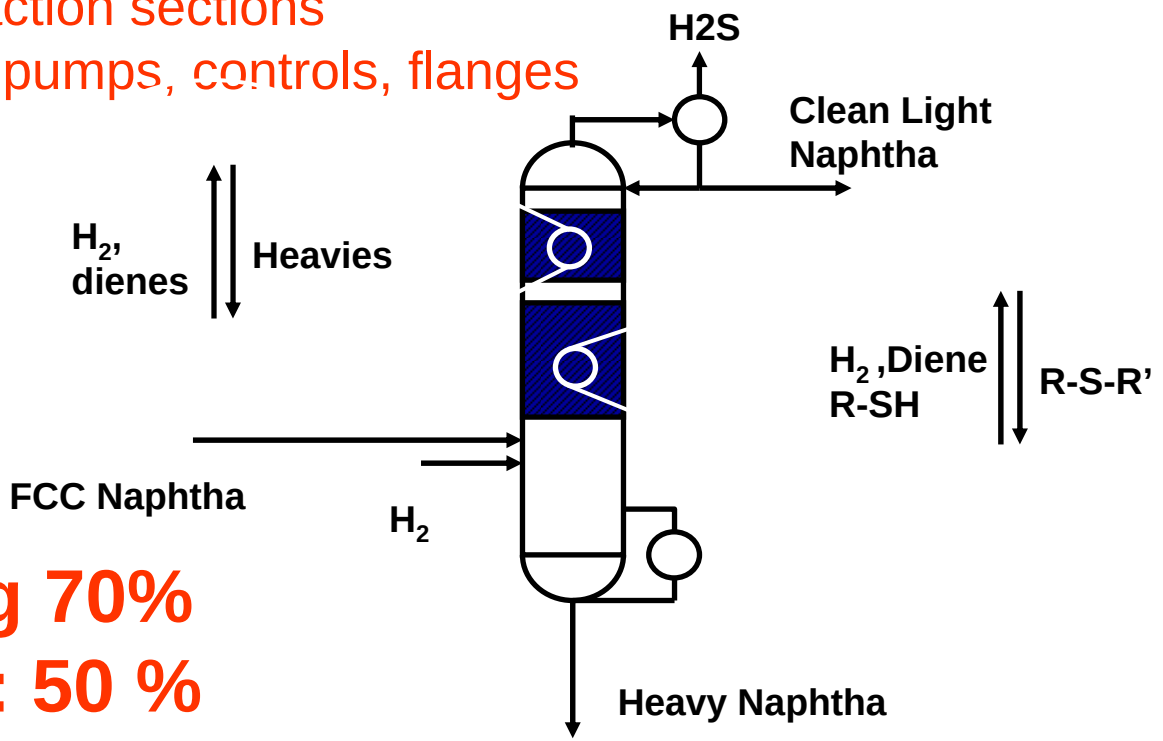
Process Elements



Energy savings: Process Intensification

Reactive Distillation from CDTECH
Thioetherification + Hydrodesulfurization + Distillation

-Functions Integrated: Mass flow, Heat exch. Reaction, Separation
-Inherent temperature controlled reactions
- Smaller loss of olefins
- Vapour flow feed to reaction sections
- Less heat exchangers, pumps, controls, flanges

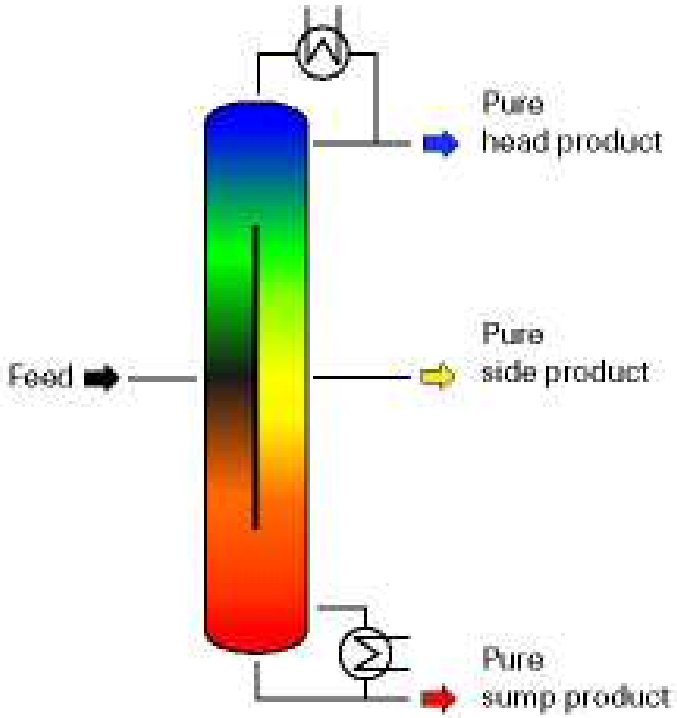


Energy saving 70%
Capex saving: 50 %

Dividing Wall vs Conventional Distillation

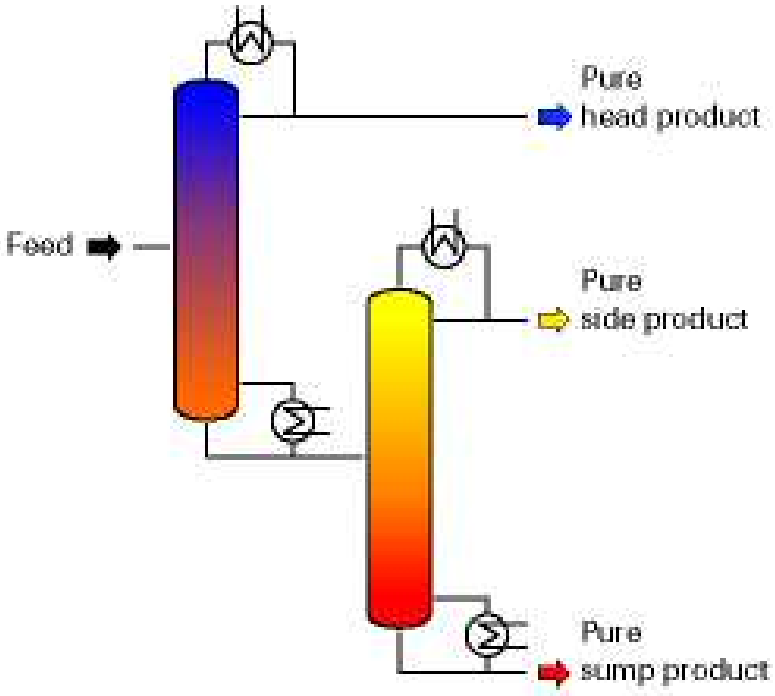
Source: Monz

Dividing wall column



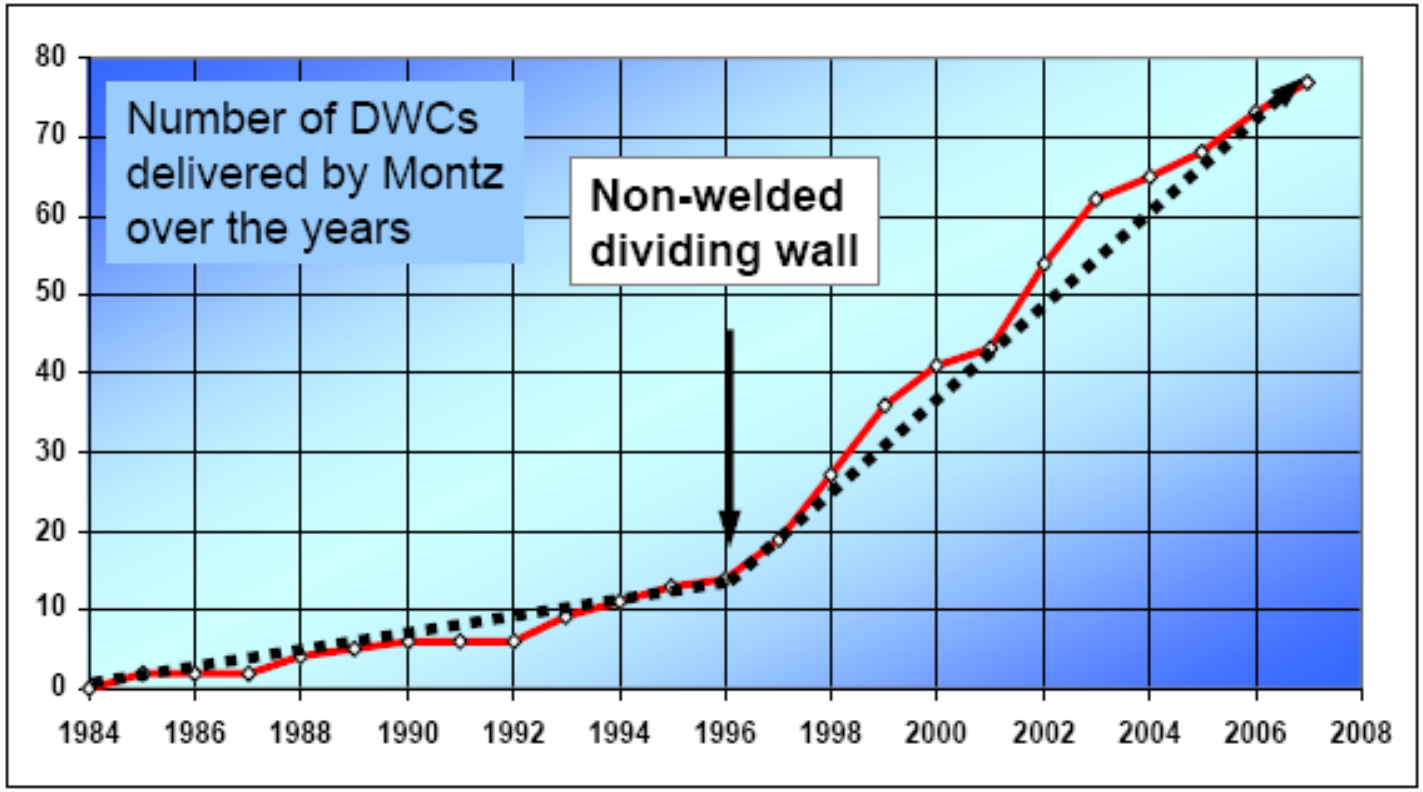
Equipment needed
- One column
- One condenser
- One evaporator
- One reflux splitter

Conventional column system

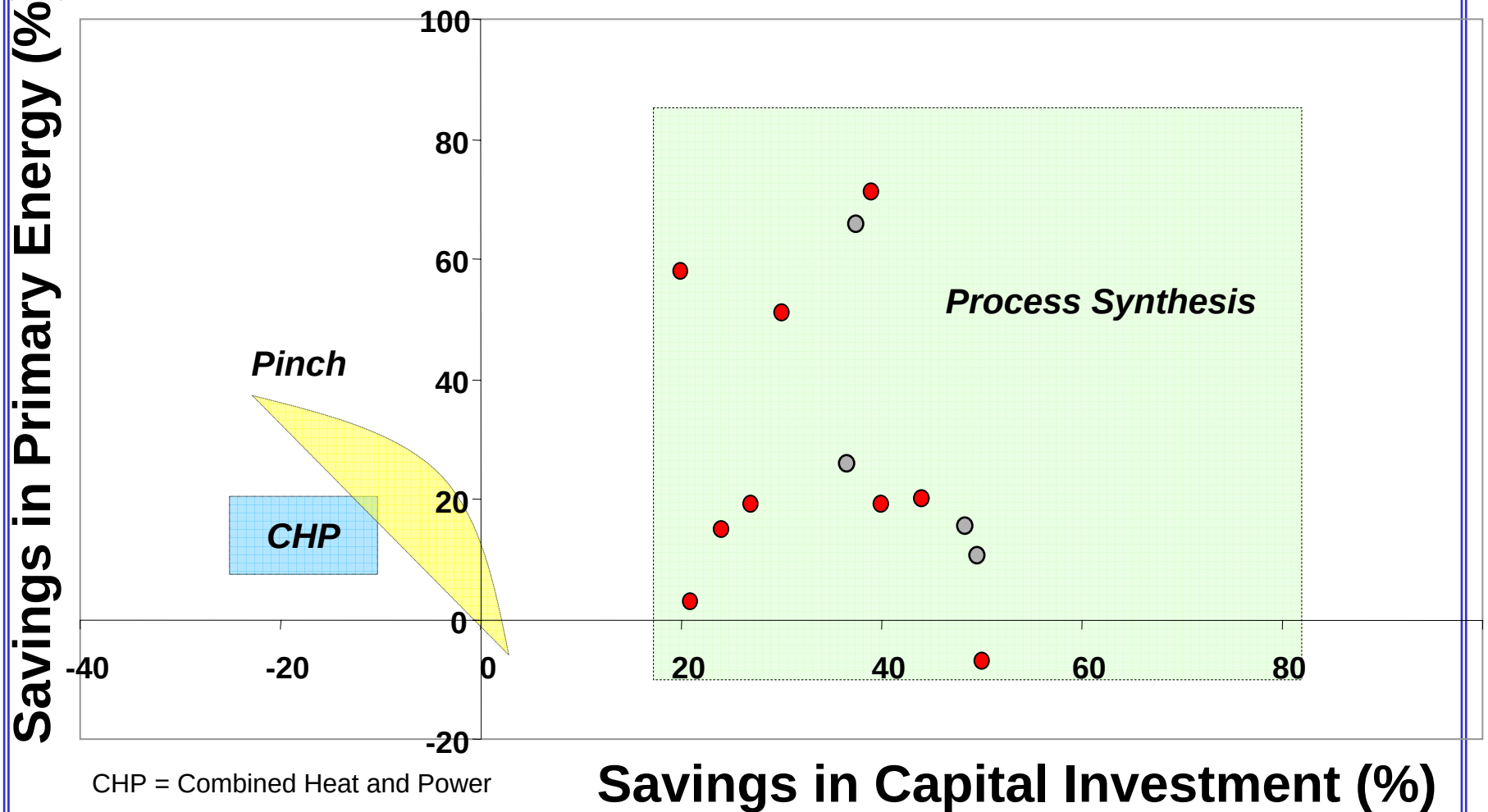


Equipment needed
- Two columns
- Two condensers
- Two evaporators

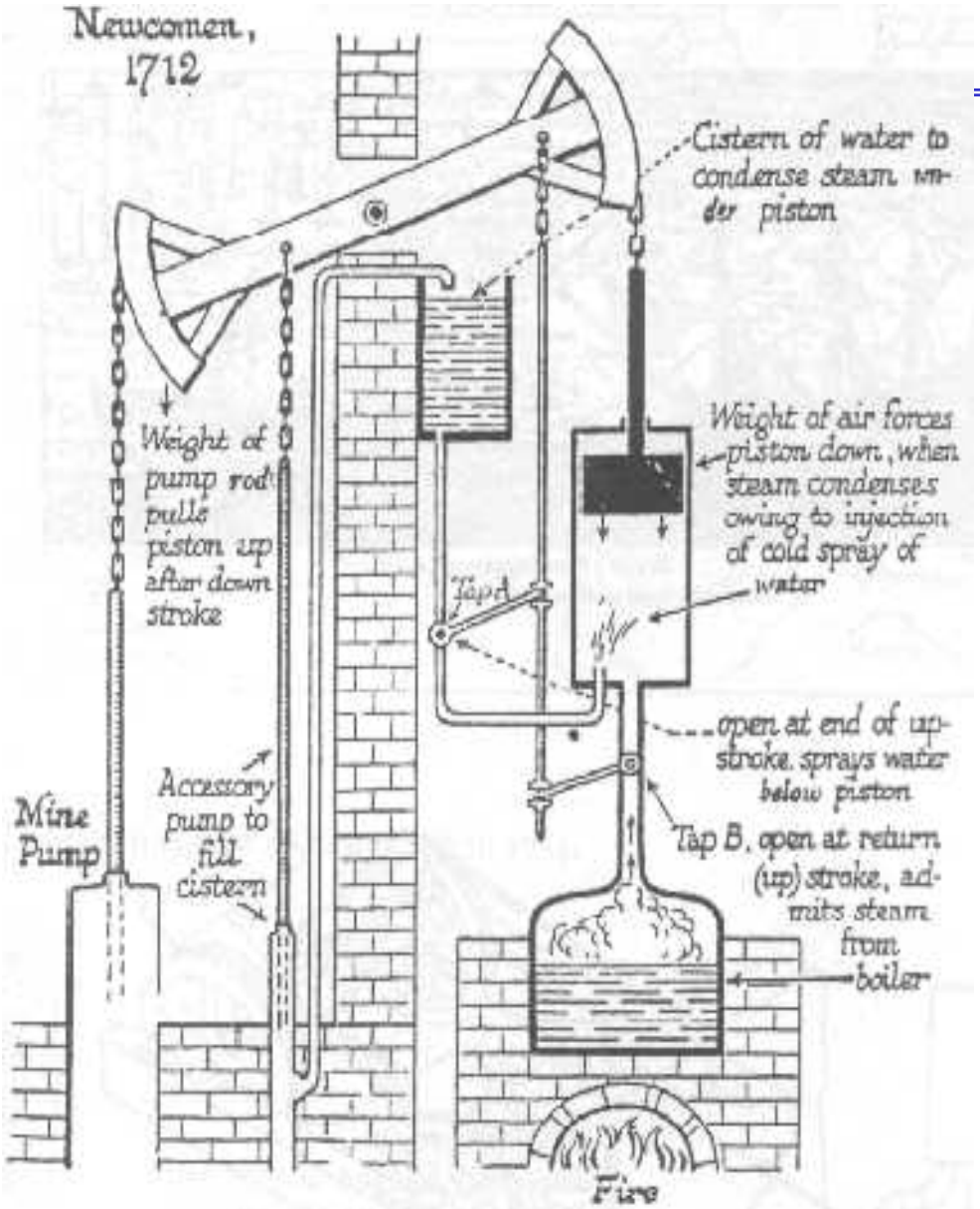
Dividing Wall Column - a rising distillation star



Increasing Energy Efficiency: PDC results



CHP = Combined Heat and Power



DIAGRAMMATIC VIEW OF NEWCOMEN'S ATMOSPHERIC OR FIRE ENGINE (1712)

Electricity production
Steam/Water Cycle
Design 1712

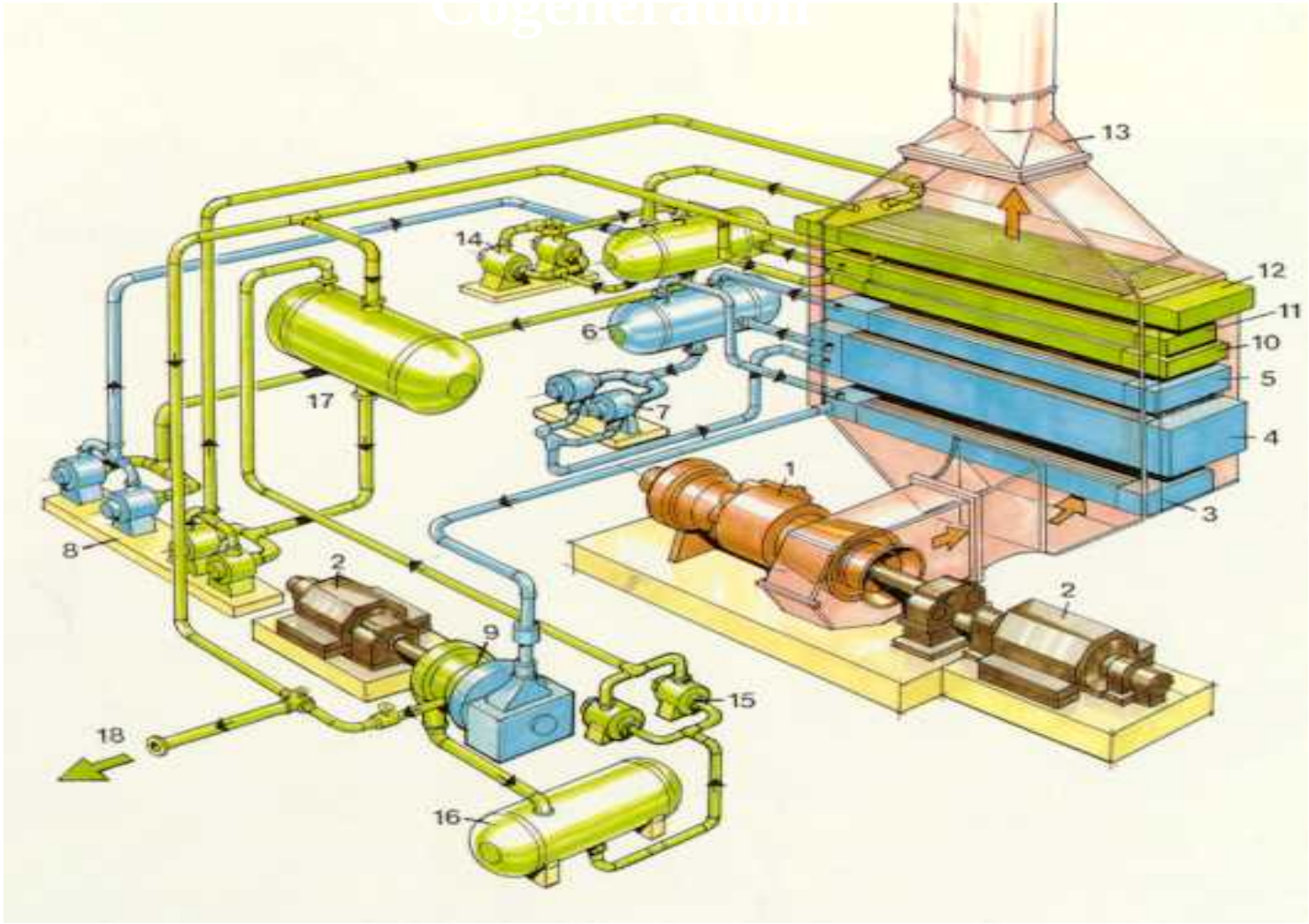
Newcomen,1663 – 1729

Diameter: 21“ (53 cm)

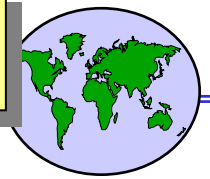
One operational till 1934

Efficiency: few percent

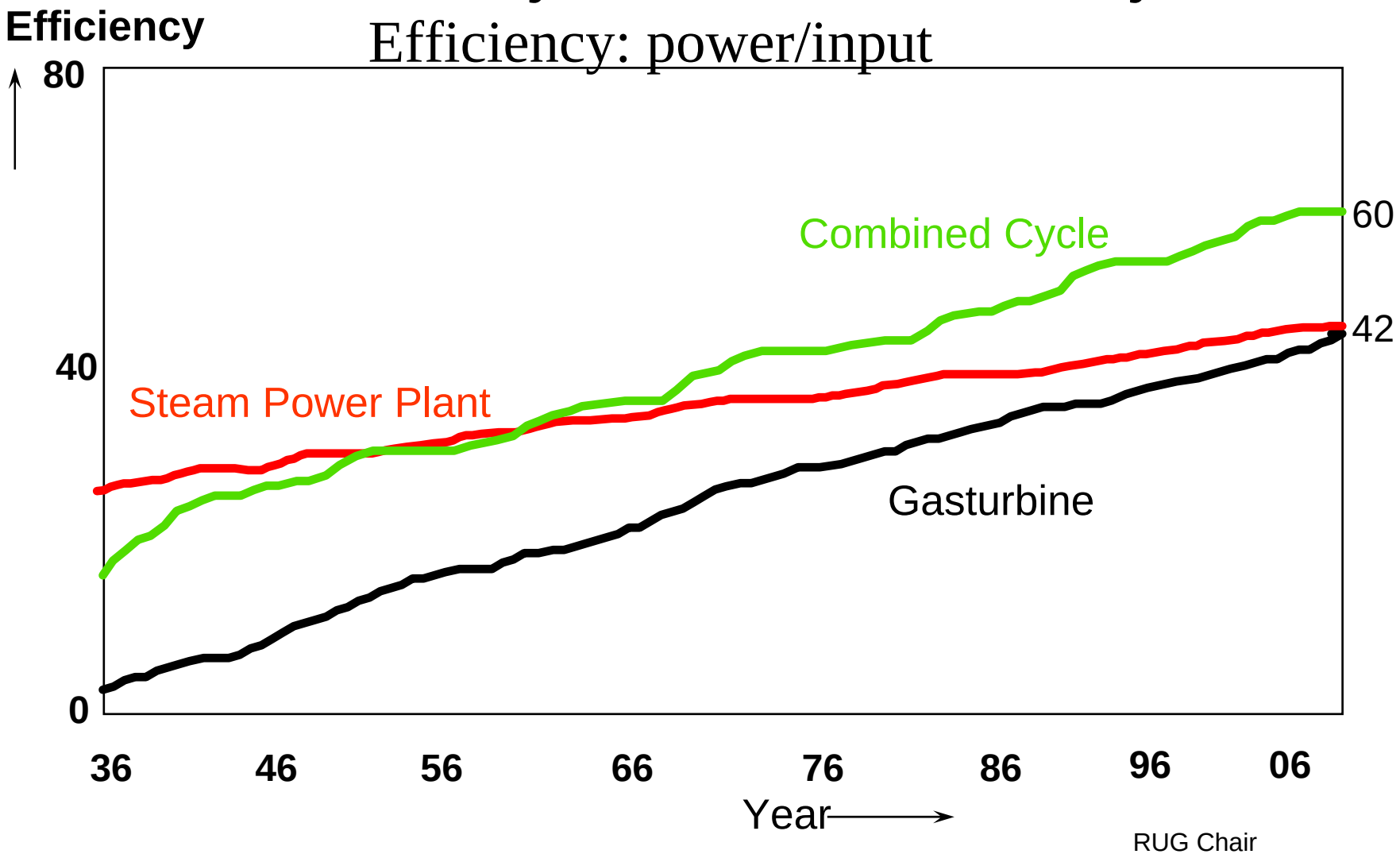
Combined Gas and Steam Turbines Power generation



Steady small step improvents typical of Process industry
Learning curve 1%/y Slope increases!

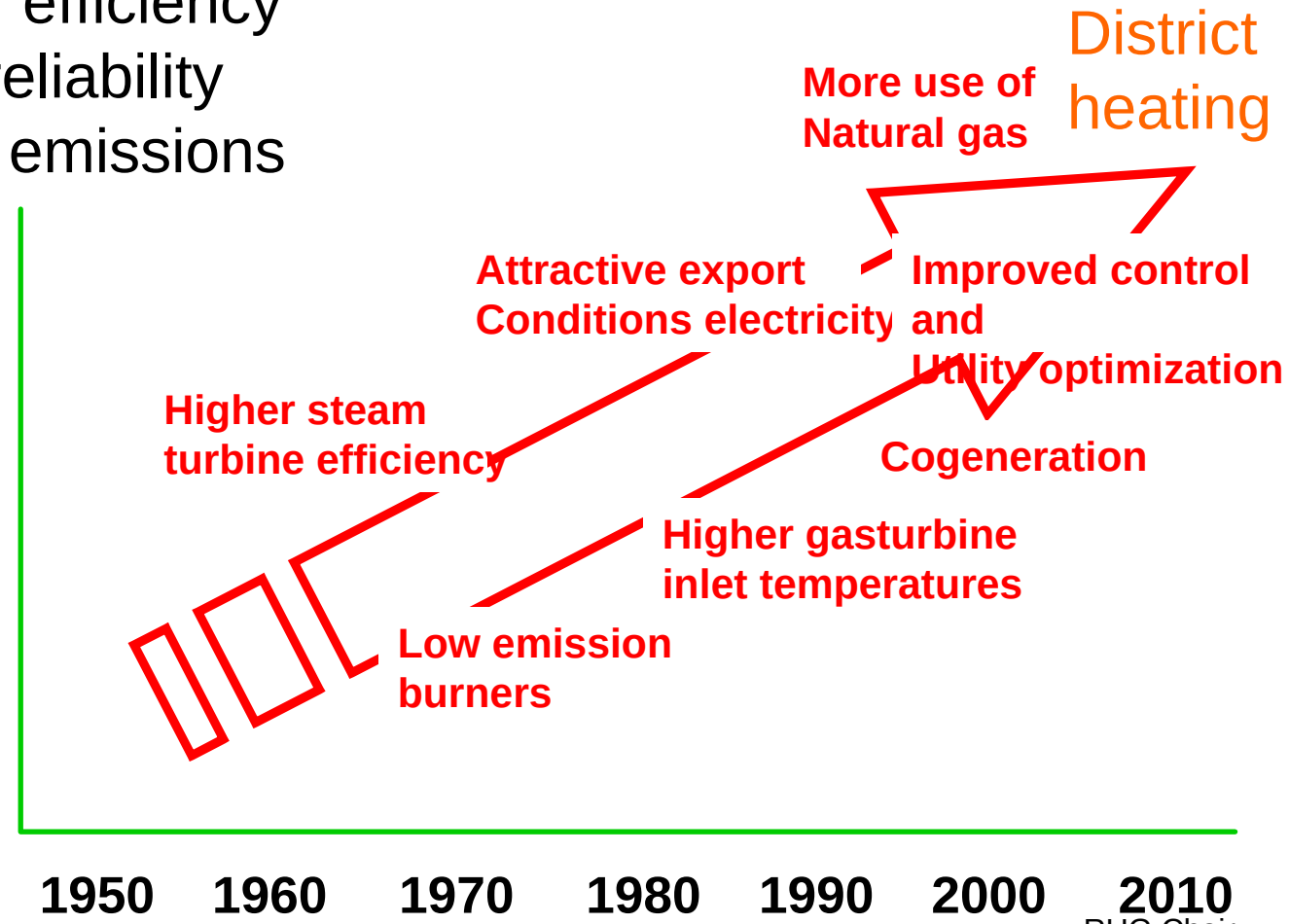


Power Effiency Gas Turbines History



Power generation Efficiency - Refinery Trend

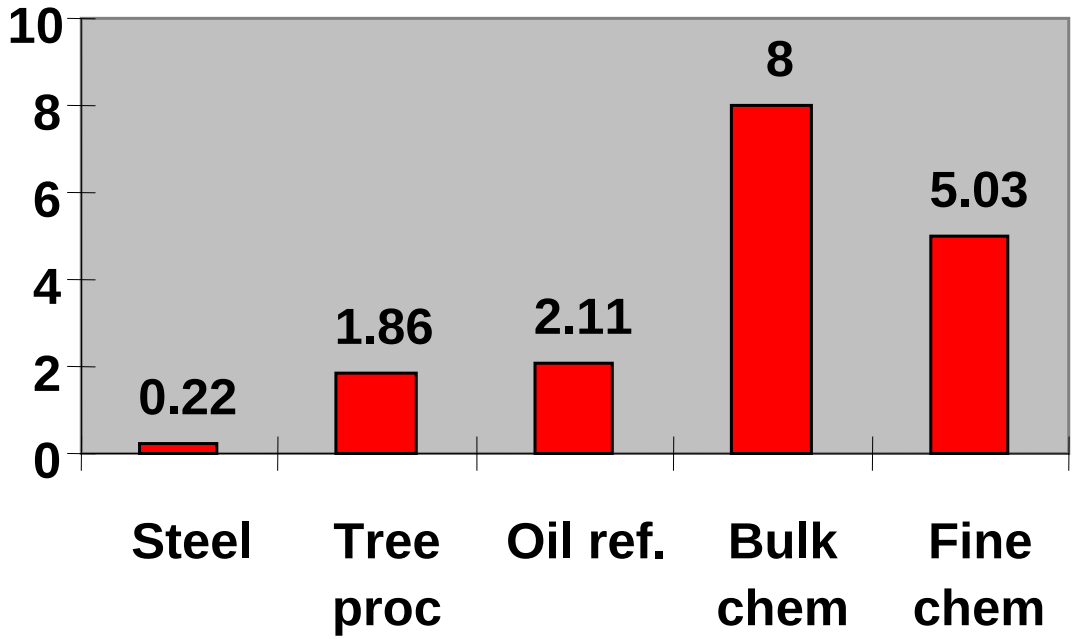
- Higher efficiency
- More reliability
- Lower emissions



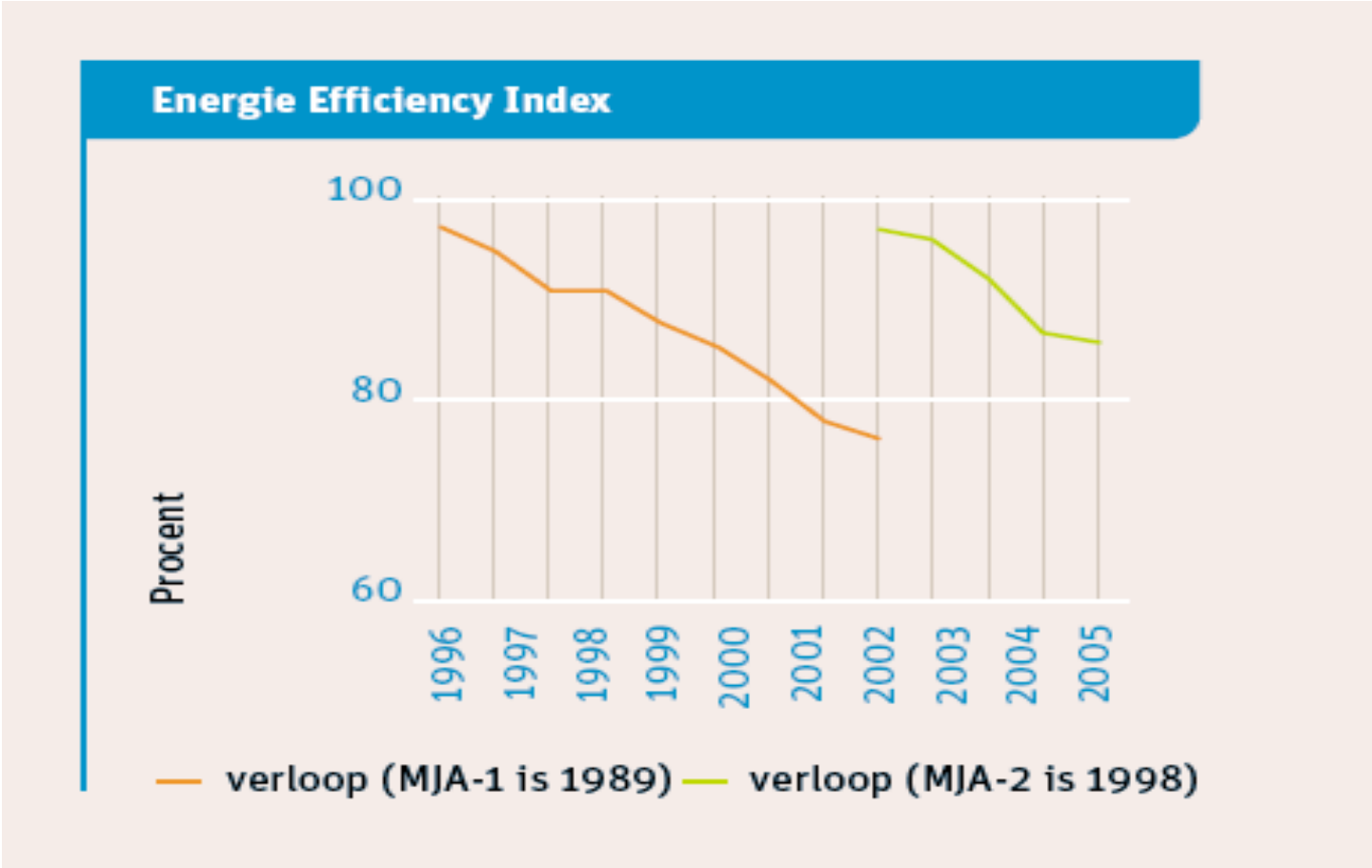
Innovation Rate Process Industries

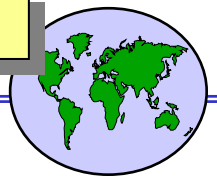
Percentage capital expenditure in new process technology

Source: Independent Project Analysis



Dutch chemical process industry
Energy savings

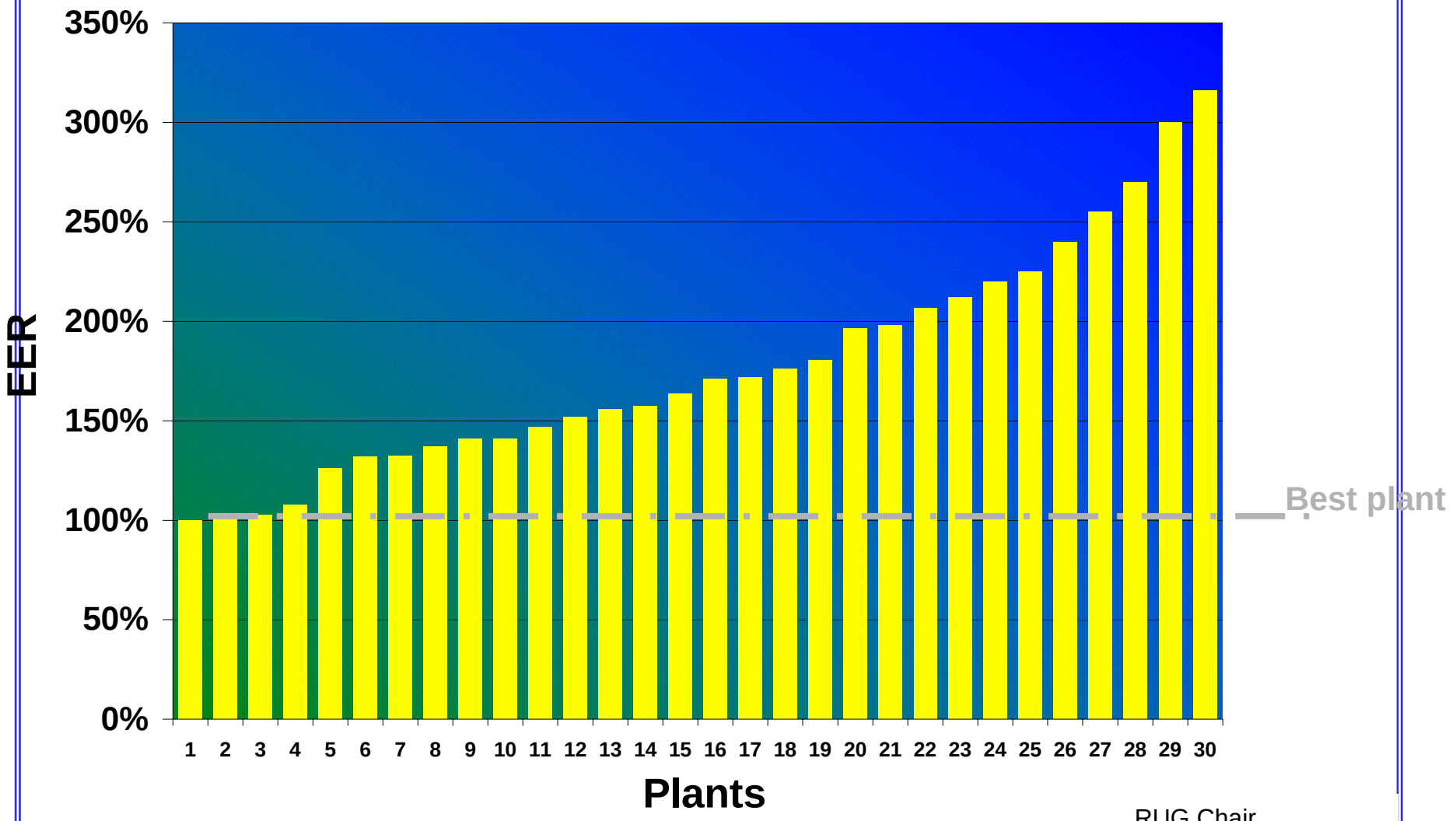




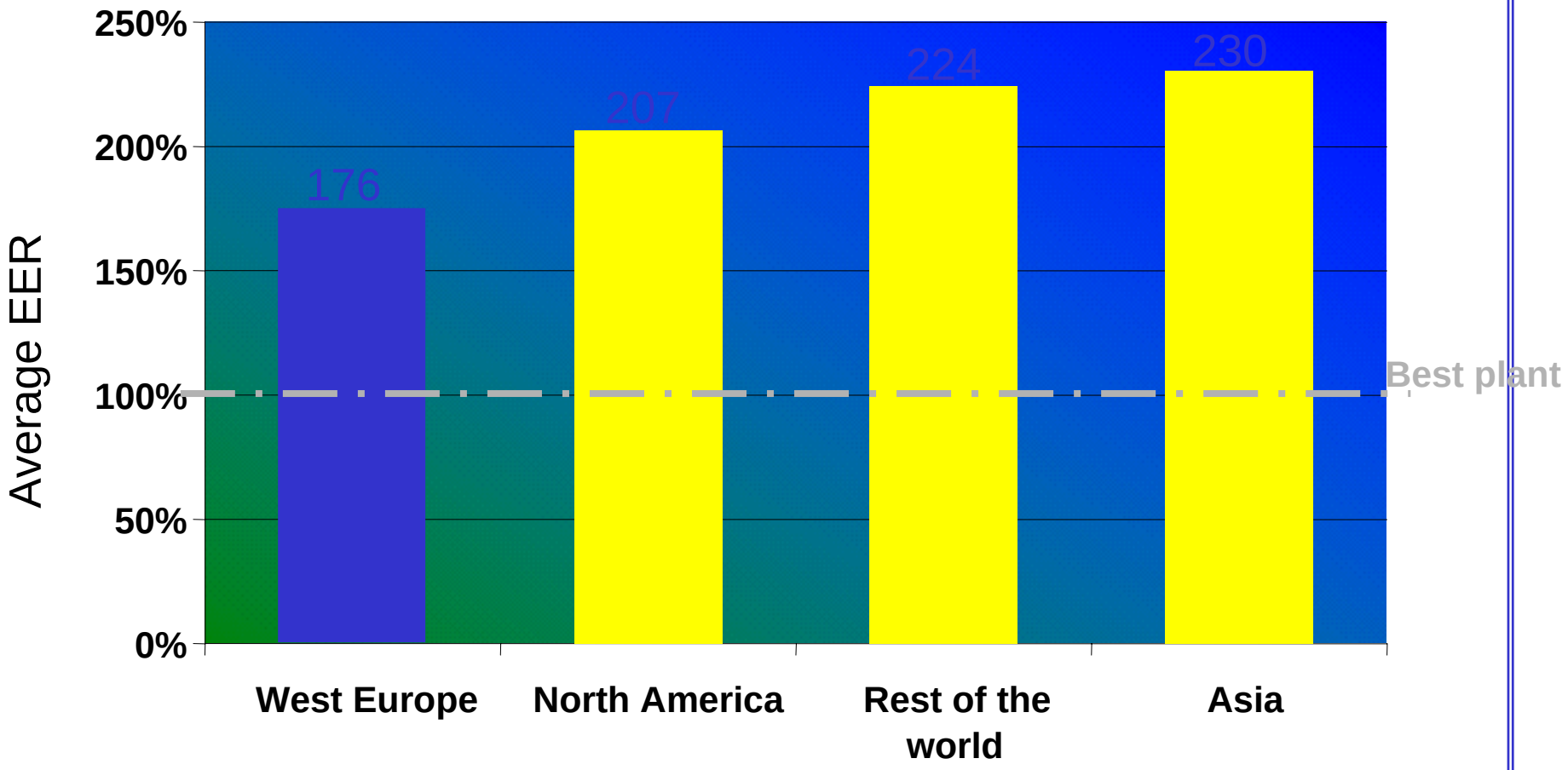
Problem statement
Impact reduction factor 4 in 25 years; How?
IMpact = P . A . C . T

- Thermadynamic Theory ➔ Feasible
- Innovation rate 2%/y ➔ Factor 2
- Economy: ➔ Scarce resources $ up ➔ Factor 1.5?
- Culture change ➔ Quantity to Quality ➔ Factor 1.5?

Typical Benchmark result



Region Comparison Chemicals



Rest of the world = Middle and South America, East Europe and Africa