



Green chemical industry

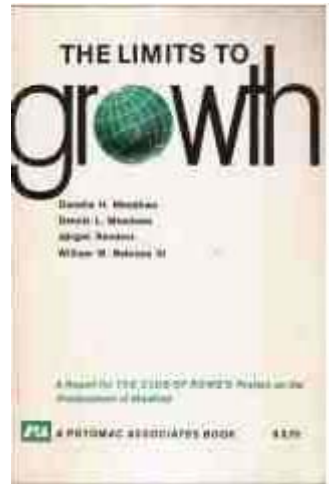
Implementing the roadmap

Arij van Berkel

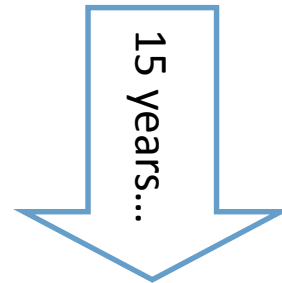




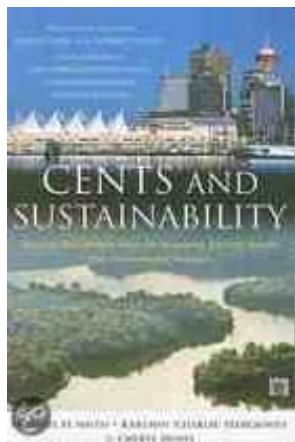
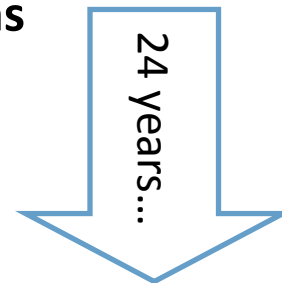
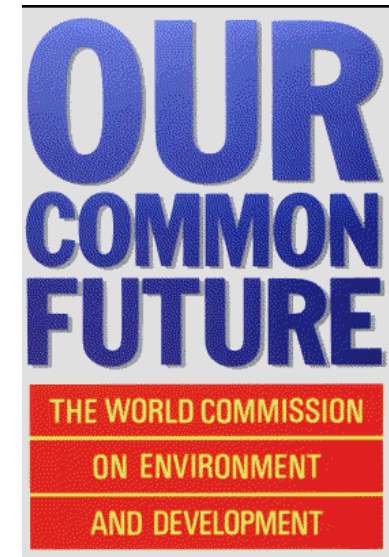
Arij van Berkel
Green chemical industry



1972: Club of Rome
Economic growth is limited by the Earth's ecosystems



1987: Brundtland committee
Introducing sustainability: growth is possible, but limited by future generations

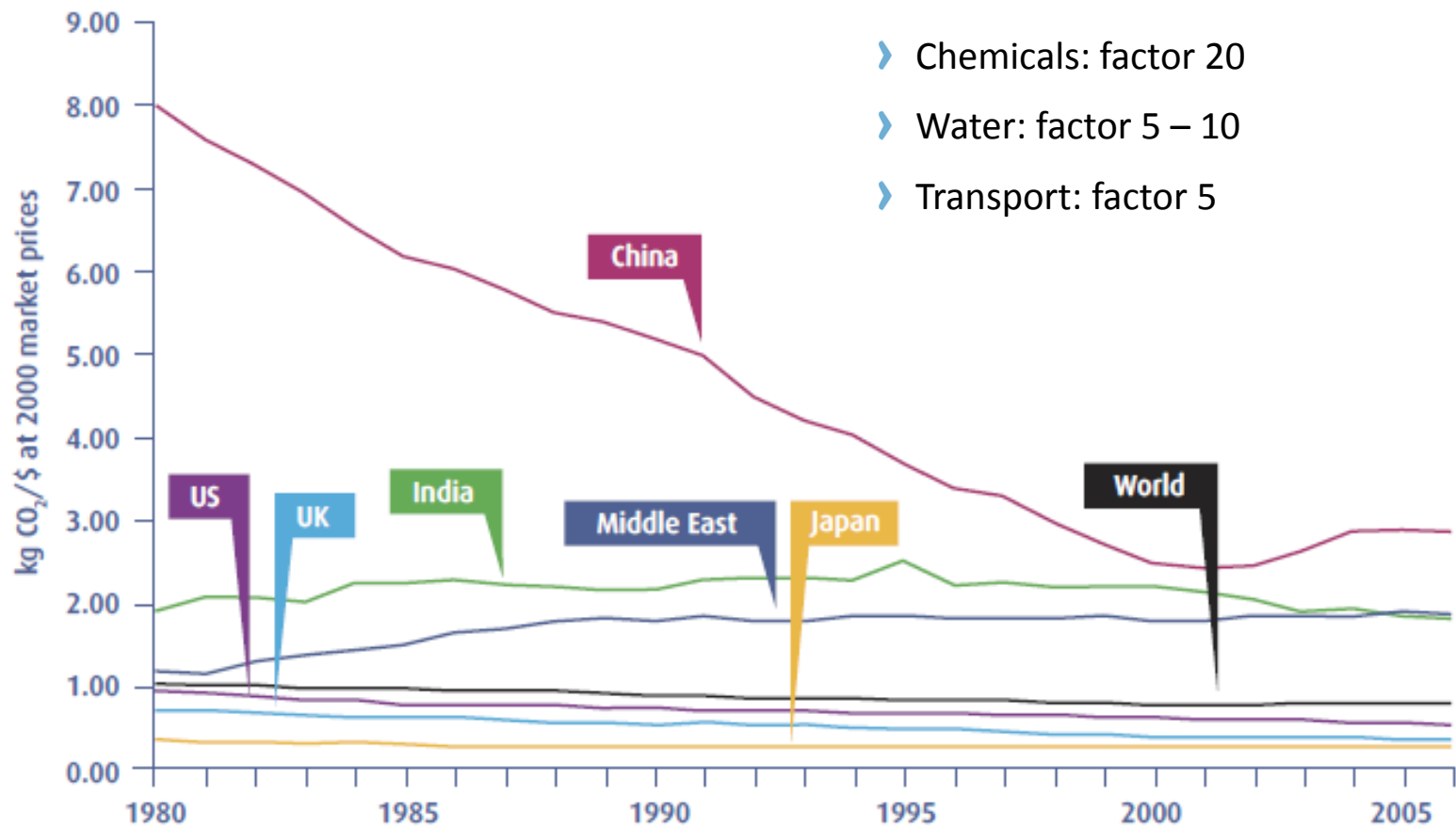


2011: UN sustainable development committee
Decoupling prosperity from natural resources



Decoupling

- › Nutrition: factor 20
- › Chemicals: factor 20
- › Water: factor 5 – 10
- › Transport: factor 5





A society in transition.....

- › Energy intensive industry should increase energy efficiency by 50%
- › New houses should be completely energy neutral in 2020
- › Existing houses should reduce CO₂ emissions with 50% in 2030
- › Introducing electric cars
- › Substantial shift to solar and wind power in 2050
- › Increase recycling of plastic and increase electricity production from waste incineration
- › 10 % biofuels in the mix in 2020
- › 30% replacement of fossil feedstock by renewables in 2030
- › Up to 30% co-firing of biomass with coal in 2030



Towards a green chemistry

The chemical industry has unique assets to contribute to the sustainability transformation:

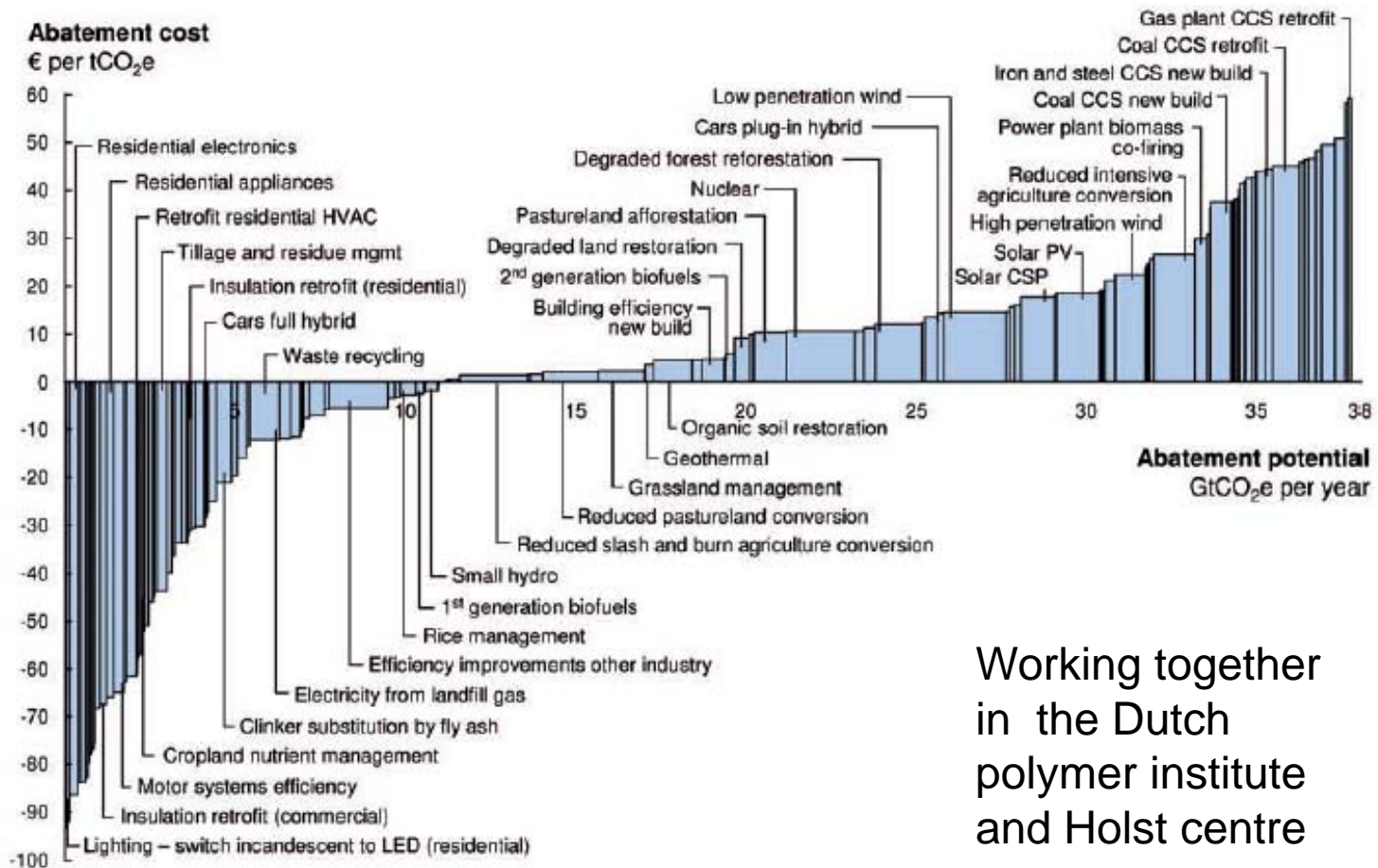
- It is at the root of almost every industrial value chain
- It has the ability to transform materials at the molecular level

Transformation of the industry at four levels:

1. Product base: sustainable alternatives for the industry
2. Raw materials base: Biobased economy
3. Production base: energy and resource efficiency conversions
4. Societal role: caring for sustainability and society



A greener product base



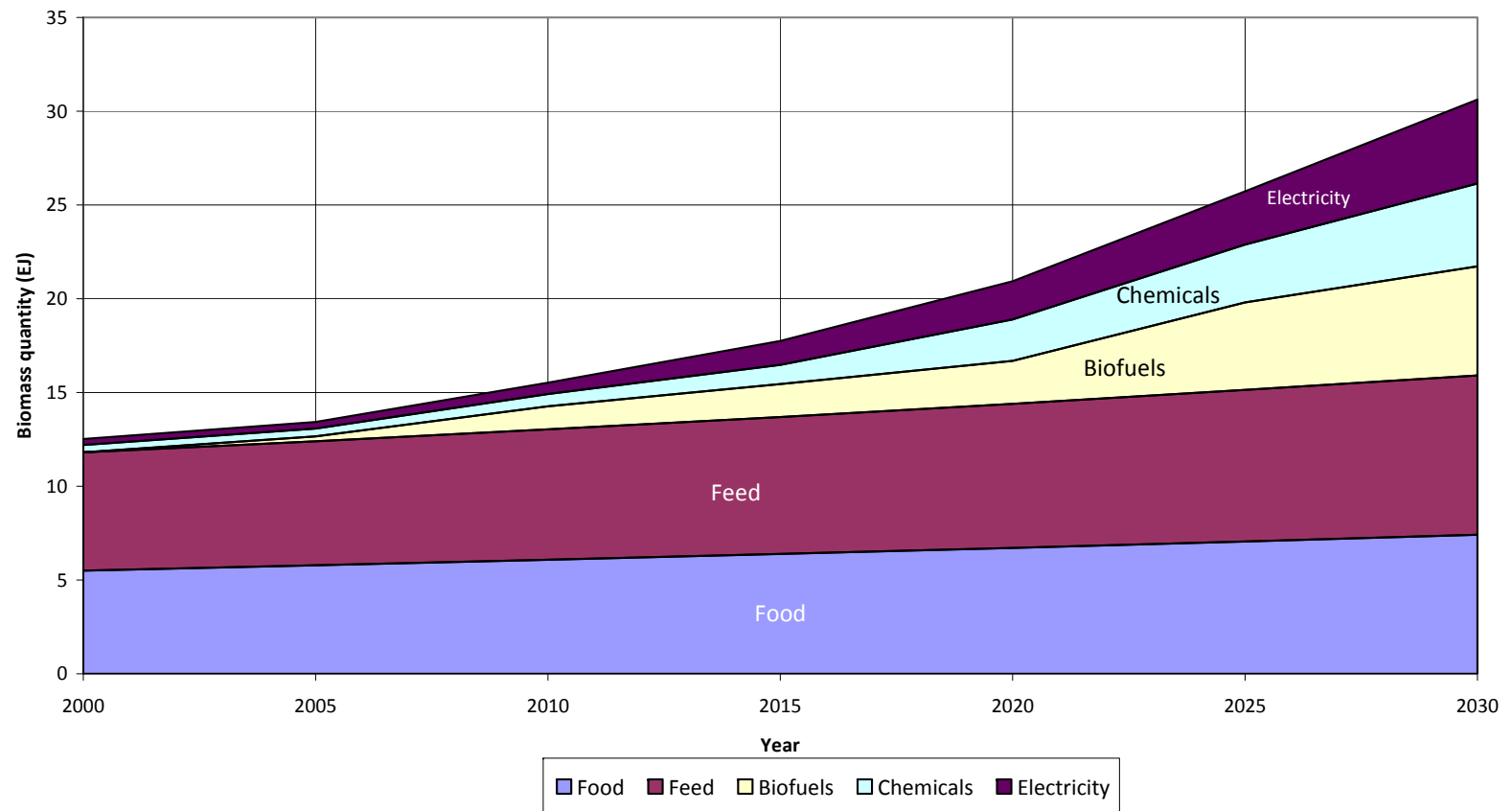
Working together
in the Dutch
polymer institute
and Holst centre

Note: This is an estimate of the maximum potential of all technical GHG abatement measures below EUR 60/tCO₂e, if each lever was pursued aggressively, not a forecast of what role different abatement measures and technologies will play
Source: Global GHG Abatement Cost Curve v2.0, McKinsey & Company



A greener feedstock base

EU27 biomass utilization forecast





A greener production base

- › Process intensification roadmap with some highlights:
 - › Higher energy efficiency
 - › Higher product yield, less effluents
 - › Higher efficiency on raw materials
 - › Lower time to market
 - › Less capital intensive



Road- map

Impact

- >1 industrial pilot/demo per year
- Integrated flexible continuous production concept demonstration
- NL equipment industry delivers innovative solutions to chemical industry

Market

- Debottlenecking
- Batch → Continuous
- Distributed production
- Feedstock/product flexibility
- Efficiency & sustainability
- Asset Light
- New product introduction & short product lifecycles

Product Service

- Process System Design & Technical Consultancy
- Continuous 2-phase reactors
- Continuous 3-phase reactors
- Integrated reaction-separation
- Continuous crystallization
- Membrane based separation
- Small-scale distillation
- Distributed measurement
- Multi-phase sensor technology
- Integrated process control

Knowledge

- Process System Engineering
- Techno-economical evaluations
- Reactor technology, Membrane technology, Crystallization, Analytics
- Manufacturing technology
- Manifolding & flow distribution
- Piloting & demonstration
- Fluid dynamics & process modeling
- Model Predictive Control

Organi- zation

- Lab/bench facilities (Leeghwaterstraat, Rijswijk)
- Piloting & demonstration facilities (Plant One)
- Network of chemical & equipment partners, key accounts
- Cooperation with KI's: TUD, TUE, UT, VITO, ECN; Cooperation with ISPT & Syntens
- Internal cooperation: Delft, Eindhoven, Apeldoorn

2012

2014

2016

2018

2020



A changing societal role

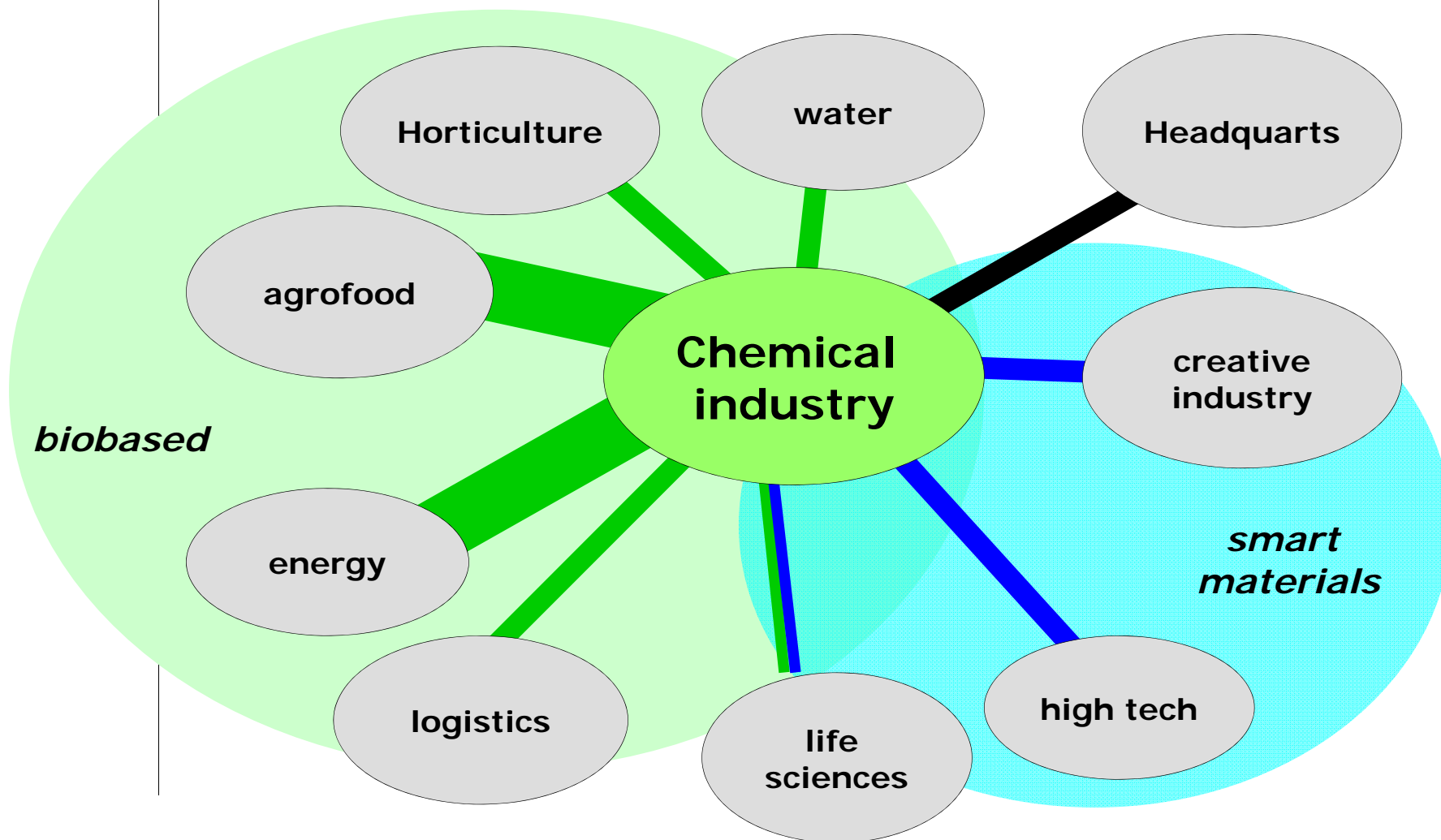
Sustainability through cooperation in networks:

- › Responsible care for product safety
- › Exchanging flows with other sectors (food, agro, metal)
- › Taking responsibility for education
- › Expanding supplier network

How do we manage the interactions?



Managing the cross sectorial network





Structurally working towards sustainability

- › Analysis tools across the complete spectrum:
 - › Financial risks
 - › Labour risks
 - › Environmental risks
 - › Safety risks
 - › Operational risks
- › A single framework to assess and improve on the risk profile
- › Forming new networks to create solutions through innovation