Challenges of the transition to the circular economy

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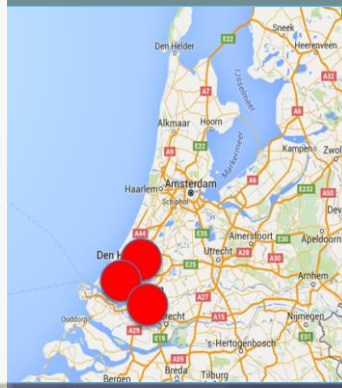
Chair, Leiden-Delft-Erasmus Centre for Sustainability

Nuffic-Neso Russia Lectures, Moscow (22.10.18) and St. Petersburg (24.10.18)

Centre for Sustainability



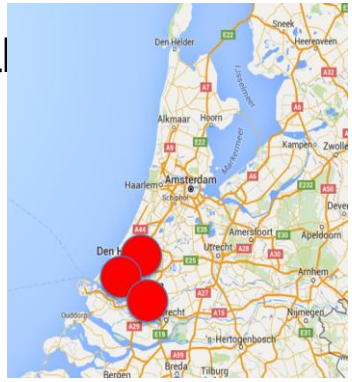
Universiteit Leiden The Netherlands

TU Delft Delft University of Technology

Erasmus University Rotterdam

Where I come from

- **Chemist by training, PhD in LCA and Policy research**
- **Ministry of Environment (1988-1990)**
- **TNO (large not for profit research organisation, 1990- now, 30% since 2013)**
- **Director and professor, Institute of Environmental Sciences CML, Leiden University (>100 staff, 2013-now, 70%)**
  - Circular economy and resource-efficiency
  - Biodiversity and Natural Capital
- **Chair, Leiden-Delft-Erasmus Centre for Sustainability (virtual 3 universities, about 300 researchers, 2015-now)**

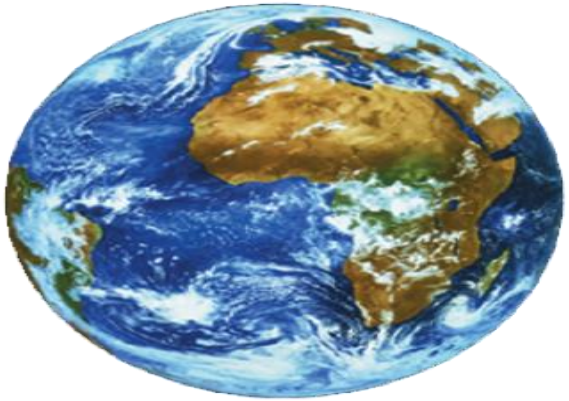


Why circularity and green growth?

The future we want, and the present we have

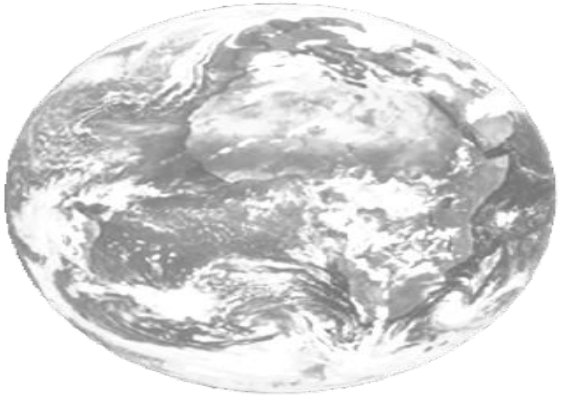
What we want

- An economy based on justice, exploiting people nor planet
- A world where people can live in dignity
- A world where people can live in peace



Our current world

- An economic system that is not sustainable
  - Carbon: to a 7ºC world or 80% reduction by 2050
  - Water: 40% shortage by 2030
  - Biodiversity: mass extinction, we use 35% of biomass
- Large difference in wealth, billions of poor
- Pressure on resources that may prompt conflicts



Global resource use at 7% growth

Doubles global economy every 10 years…

..10-fold every 35 years

After about

- 100 yr: an amount of energy equal to the full solar influx on earth
- 200 yr: all water on Earth, including sea water
- 300 yr: a resource volume equal to the whole earth crust
- 400 yr: an oil barrel the size of the earth

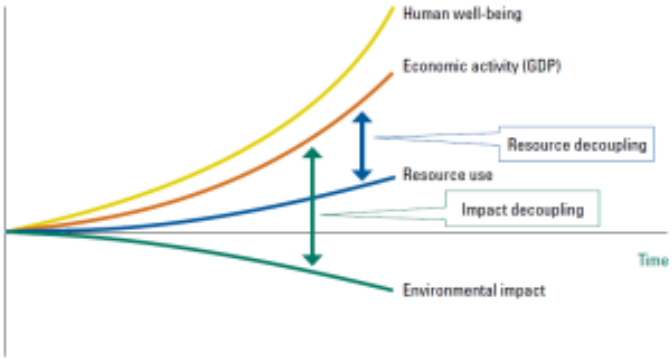
At 3%, these numbers roughly double

A circular economy – some (in)convenient truths

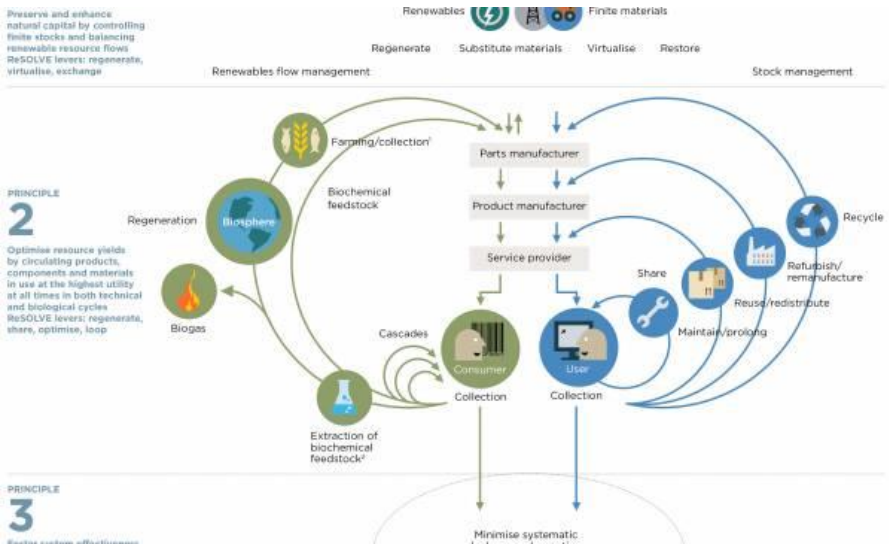
Key answer: doing more with less

- **EU Circularity package**
  - ‘Decoupling’
    - Enhance quality of life
    - With less growth of GDP
    - With less resource use
    - And minimal emissions
  - ‘Circularity’
    - Prolonging product life
    - Repair
    - Re-use
    - Remanufacturing
    - Recycling

- **EU Raw materials initiative**
  - Enhance knowledge base (EIT KIC Raw materials)
  - Enhance normal and urban mining in Europe



Source: UNEP International Resources Panel

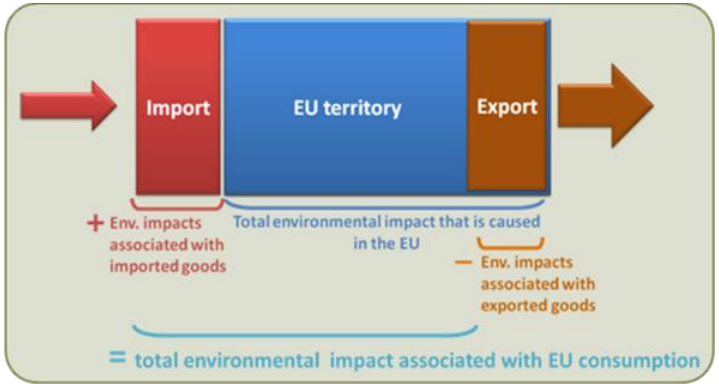


Source: Ellen MacArthur Foundation

Accounting system: environmentally extended input output

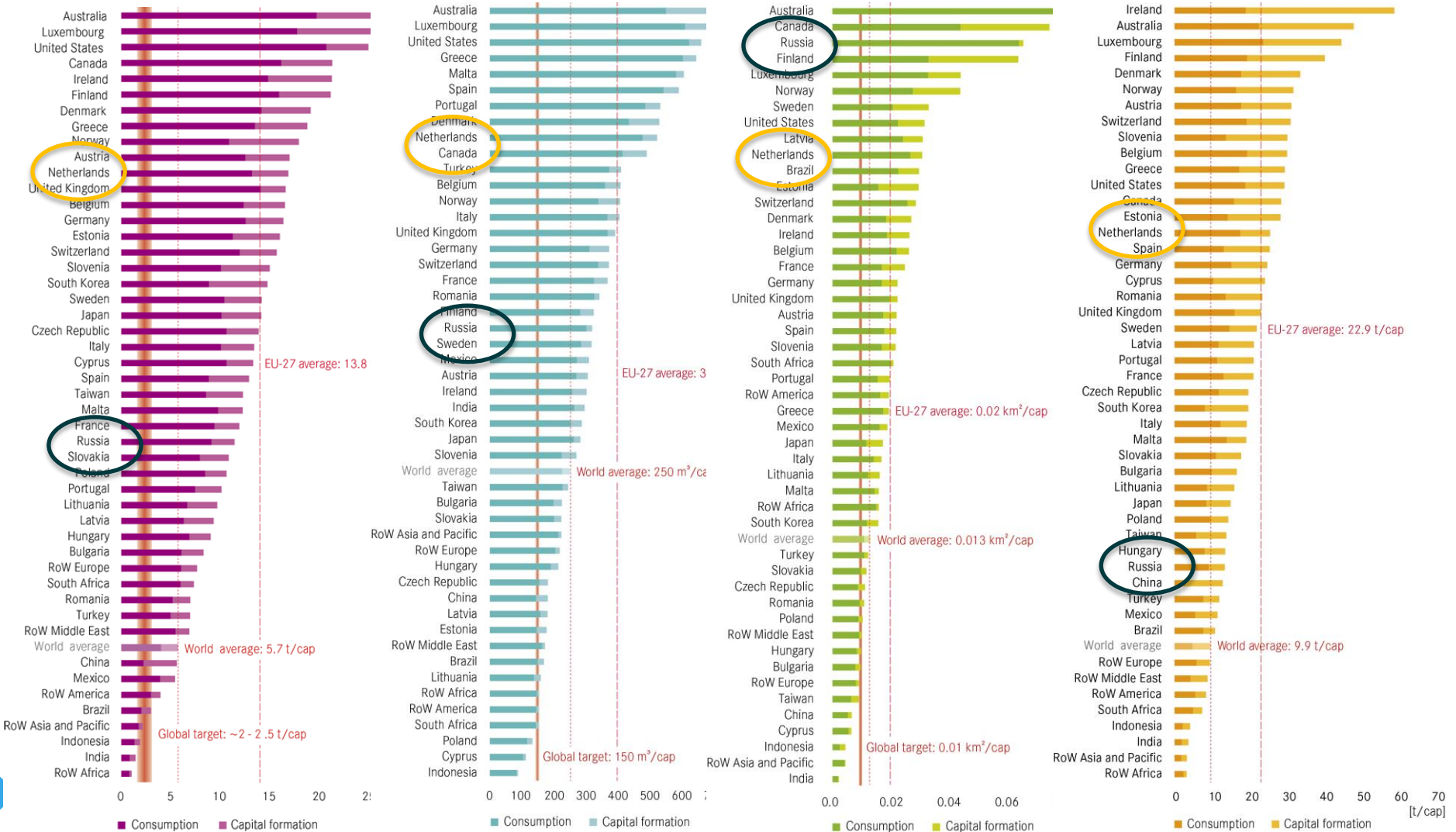
- Production oriented / territorial
  - Resource extraction and emissions within boundaries
  - Neglects upstream emissions and resource use for making imports

- EE IO production to consumption
  - Example: 5 Euro coffee at Starbucks
    - 3 Euro for Starbucks = Restaurant
    - 1 Euro for roaster = Food industry
    - 0.5 Euro for transport = Transport
    - 0.25 Euro for farmer = Agriculture
    - 0.25 Euro for fertiliser, etc.
    - Impacts per sector/country per Euro known
    - Multiply -> you see how impacts of production relate to consumption
  - In essence you re-distribute global territorial emissions to consumption

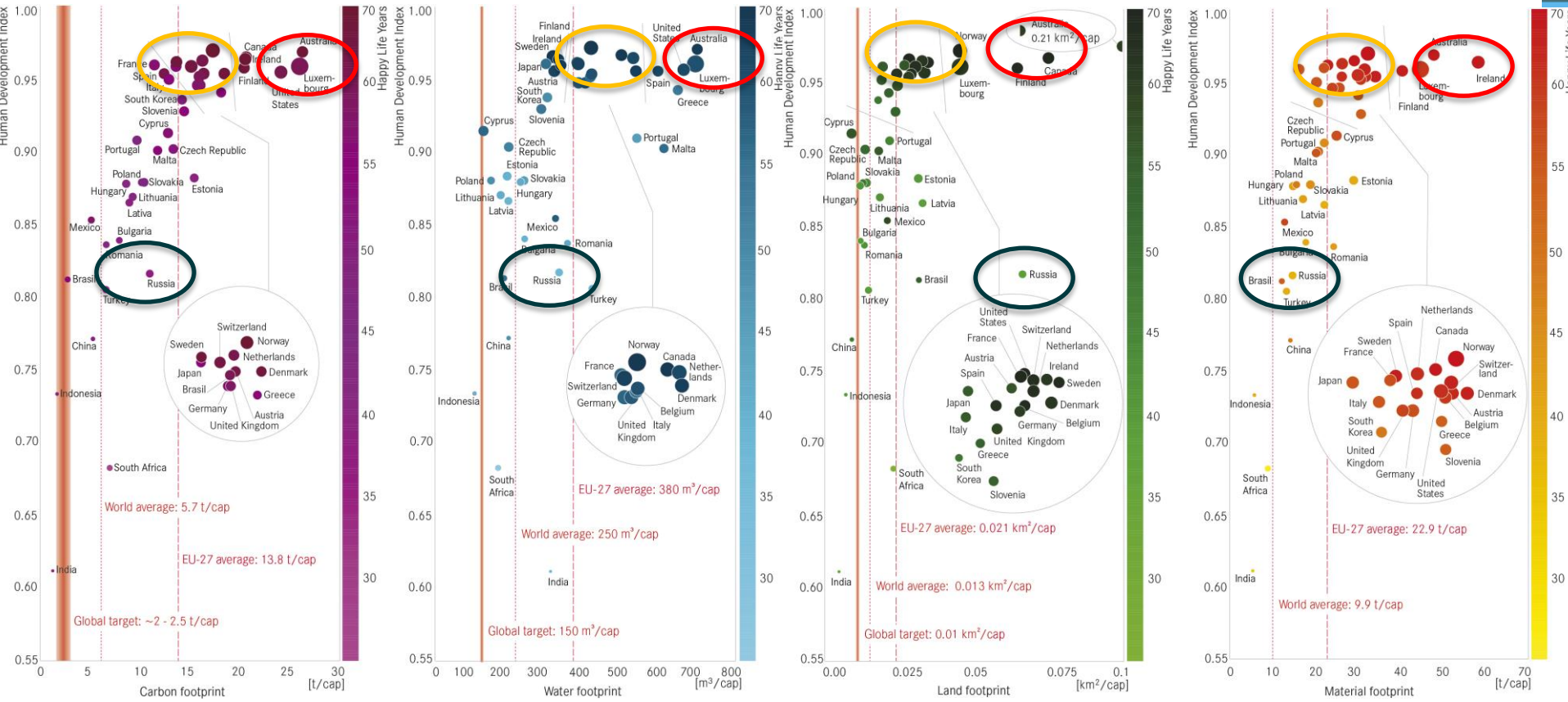


		Industries				$Y_{*,A}$	$Y_{*,B}$	$Y_{*,C}$	$Y_{*,D}$	q
Products		$Z_{A,A}$	$Z_{A,B}$	$Z_{A,C}$	$Z_{A,D}$	$Y_{A,A}$	$Y_{A,B}$	$Y_{A,C}$	$Y_{A,D}$	q_A
		$Z_{B,A}$	$Z_{B,B}$	$Z_{B,C}$	$Z_{B,D}$	$Y_{B,A}$	$Y_{B,B}$	$Y_{B,C}$	$Y_{B,D}$	q_D
		$Z_{C,A}$	$Z_{C,B}$	$Z_{C,C}$	$Z_{C,D}$	$Y_{C,A}$	$Y_{C,B}$	$Y_{C,C}$	$Y_{C,D}$	q_C
		$Z_{D,A}$	$Z_{D,B}$	$Z_{D,C}$	$Z_{D,D}$	$Y_{D,A}$	$Y_{D,B}$	$Y_{D,C}$	$Y_{D,D}$	q_D
W		W_A	W_B	W_C	W_D					
g		g_A	g_B	g_C	g_D					
C & L		$Capital_A$	C_B	C_C	C_D					
		$Labor_A$	L_B	L_C	L_D					
Environ Ext		$NAMEA_A$	$NAMEA_B$	$NAMEA_C$	$NAMEA_D$					
		$Agric_A$	$Agric_B$	$Agric_C$	$Agric_D$					
		$Energy_A$	$Energy_B$	$Energy_C$	$Energy_D$					
		$Metal_A$	$Metal_B$	$Metal_C$	$Metal_D$					
		$Mineral_A$	$Mineral_B$	$Mineral_C$	$Mineral_D$					
		$Land_A$	$Land_B$	$Land_C$	$Land_D$					

Fact 1: Rich = high carbon, water, land and material needs for satisfying consumption (‘footprints’)



Fact 2: After a threshold, more GDP does not gives a better Human Development Index



Inconvenient truth 1: there is a limit to resource-efficiency or decoupling

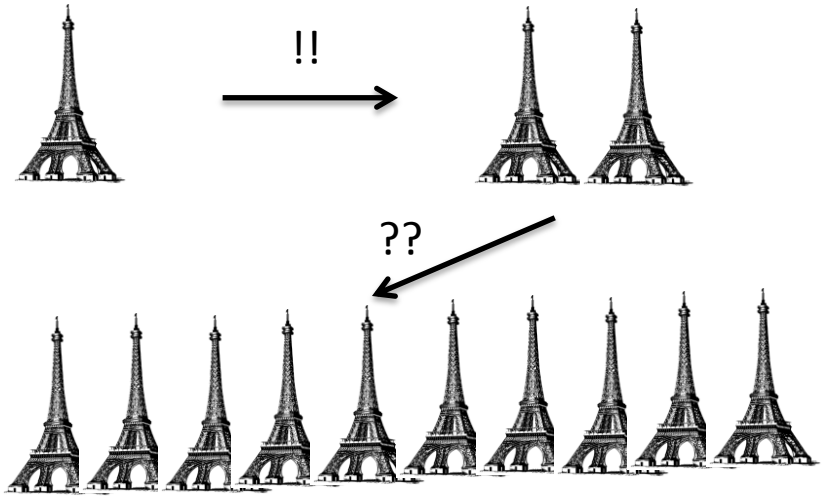
Assume zero resource use growth

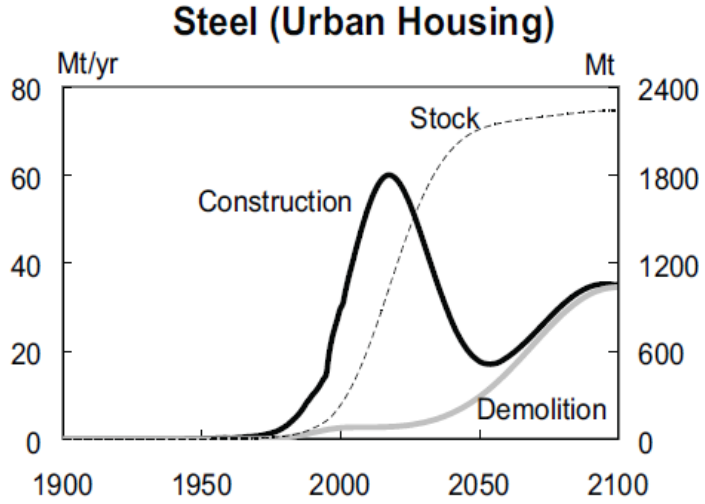
- 7% economic growth a year ->
  7% more resource-efficient a year?
- Every 10 years: doubled economy,
  hence halving resource use per Euro?
- In 100 years: transport services of
  your 1000kg car must be delivered
  using the materials in a Dinky toy

Inconvenient thruth 2: a growing econonmy inevitably needs virgin materials

- Growing economies build new infrastructure….
- ….so even if materials use is now so efficient you can build TWO Eiffeltowers from the old one…
- ….if 10 cities want an Eiffeltower, you need still 5 times more, new materials

- Even with the best recyling you will have some degradation…….
- ……so energy to upgrade





Mingming Hu, CML, 2010, steel in Beijing

Inconvenient thruth 3: scarcity will not drive it – on the short term

Type of resource	% global extraction	Basis for planetary limits	Required resource-efficiency gains	Reference
Metal ores, industrial minerals	**10%**	Absolute scarcity (varies by metal).	**Mixed** (important market failures)	EC (2010); Kleijn (2012), Graedel and van der Voet (2010).
Fossil fuels	**20%**	CO_2 emission targets: Factor 5-10 reduction for 2°C target	**Factor >10** (for the 2°C goal)	IPCC (2007), Stern (2006), Meinsausen et al. (2009)
Construction minerals	**40%**	Absolute scarcity less relevant	**Limited** **(unless energy intensive materials)**	WRI (2006)
Biomass	**30%**	Max human appropriation of net primary production. HANNP = now 30-35% of available biomass	**Factor 2** (with 50% more agricultural production in 2050 means a 25% reduction of current pressures; more if stopping biodiversity loss requires reductions in land, water and biomass use)	Vitusek et al. (1986), Haberl et al. (2007).
Land	p.m.	Available bioproductive land		Erb et al. (2009), OECD/FAO (2009); Nature (2010a and b), WWF (2010)
Water	p.m.	Renewable supply (by region) 2030: Global 'water gap' of 40%		Hoekstra and Chapagain (2007), Water resources group / McKinsey (2009)

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Inconvenient truth 4: If resource-efficiency is an answer: how circular can an economy become?

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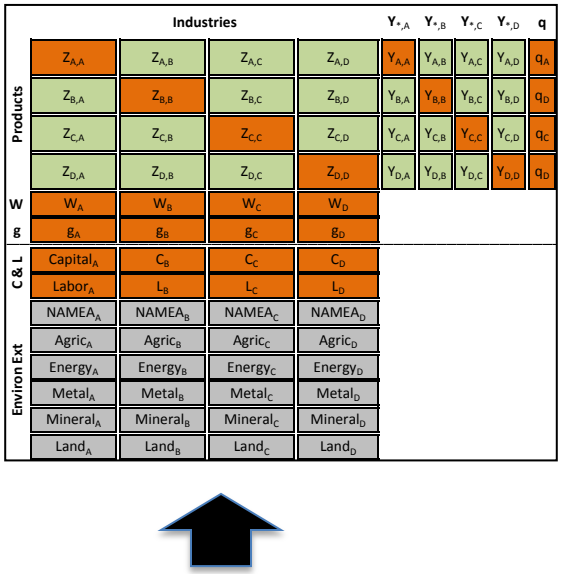


- **20% fossil fuels** -> 90% burned
- **30% biomass** -> largely eaten (apart from wood, food waste)
- **10% metal ores / industrial minerals**
- **40% ('building and construction') minerals** -> for sand and gravel you may debate the need for circularity
- *=> interesting to see how a more closed PSUT/PIOT reduces emissions and , energy use and (critical) resource use*

However, we must start the transition now!

Circularity may not buy us *eternal* growth

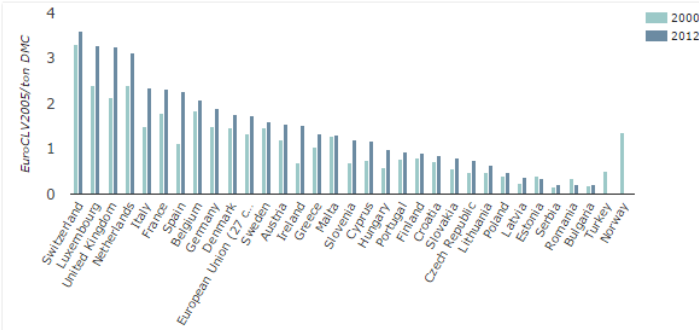
But it will give up to 20 times more wealth

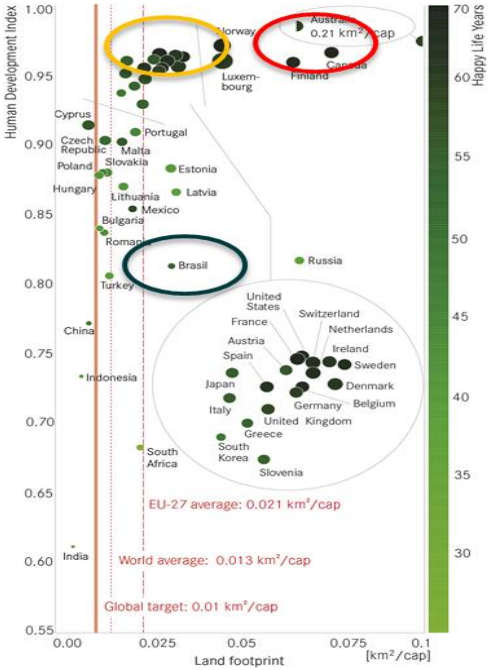
- Circularity: 4-5 times more economic activity in the same planetary limits
- Focus on Human Development: 4 times more wealth with the same level of economic activity

And we have to start now

- Transitions take time
- Investments now create lock ins
- So invest in circular, green growth now!

Figure 3: Resource productivity (GDP/DMC) in 32 European countries (2000 and 2012)

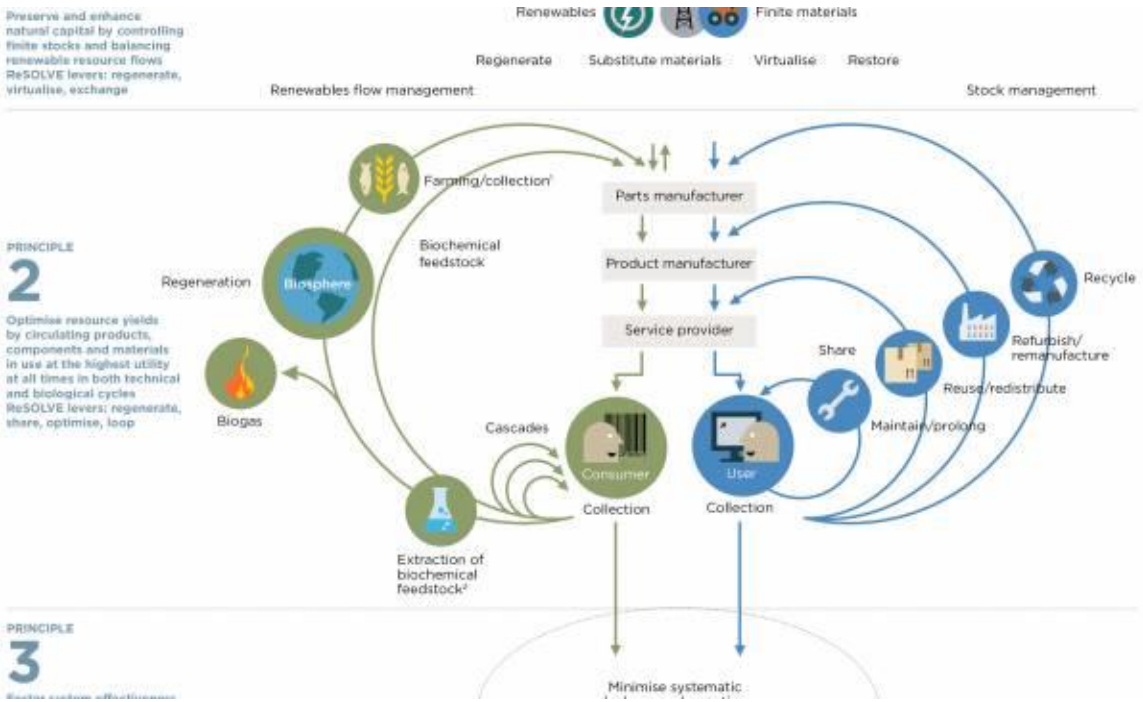




How to make the transition to a circularity

What is circularity?

- Prolonge product life, Repair, Re-use, Remanufacture, Recycle



Source: Ellen MacArthur Foundation

Four knowledge fields

1. Environmental & economic system analysis:
   - Current material flows & value added creation
   - ‘Hot spots’ and scenarios for improvement

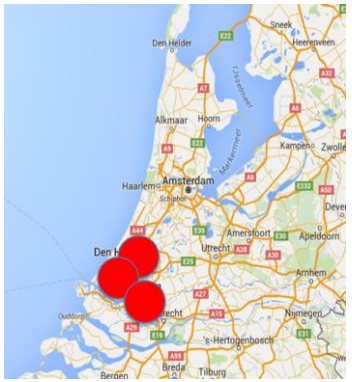
2. New, circular technologies and designs
   - That reduce primary resource use

3. New, circular business models/value chains
   - That support circular technologies and designs

4. New policy & governance
   - Markets alone often will not deliver circularity

Central in crucial activities I am involved
- Leiden-Delft-Erasmus Centre for Sustainability
- EU PhD Training Network Circuit (15 PhDs)

Leiden-Delft-Erasmus Centre for Sustainability



Focus: Research & Education

Economic and environmental system analysis Leiden-CML, EUR	**Value chains** (business, design, consumers) EUR-RSM, TUD-IO
Clean Technology TUD	**Policy** (law, governance, transitions) TUD-TBM, UL-FGGA EUR-FSW&DRIFT

CIRCUIT Circular European Economy Innovative Training Network

Natural resource use & economics

Changes to circularity – how to measure it?

- **Economic & Industrial ecology tools**
  - LCA, Material flow analysis, Input-output
  - For assessing resource use hot spots…. and improvement options

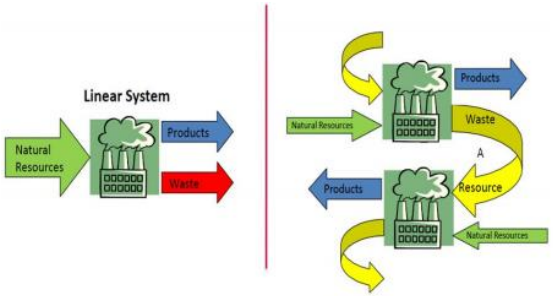
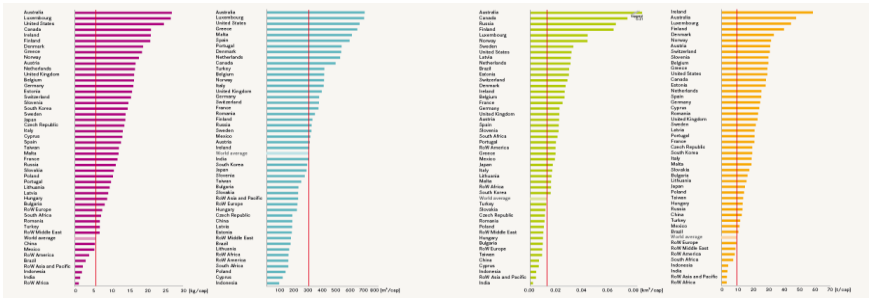
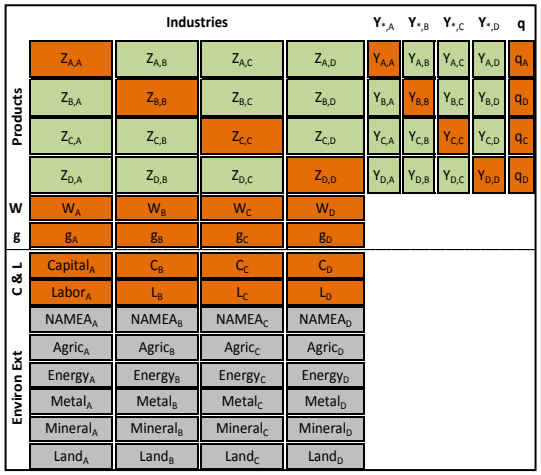


Figure 2-2 Schematic image of industrial symbiosis

- **Country footprints (e.g. Exiobase MR Environmental Input Output database)**
  - Carbon
  - Water
  - Land
  - Materials



- **Priorities (80% of impacts)**
  - Food -> reduce animal food
  - Mobility -> reduce cars, flights
  - Electrical appliances -> energy efficient
  - Housing, heating and cooling



Exiobase (orange: country Input-Output table incl. final demand; green: trade between countries; grey: emissions and resource extraction by sector)

- 43 countries + 5 Rest of continents
- 160 sectors
- 30 emissions
- 80 resources
- Water, land
- 15 types of labor, added value

Clean technology for resource management

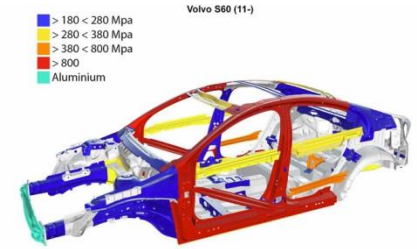
Changes to circularity – what technologies?

- **Developing technologies enabling**
  - Low impact and efficient mining
  - Low-impact industrial production
  - ‘Engineering out’ critical materials
  - Reducing complex composition of products and materials
  - Developing high-strength, low-weight materials
  - Design for life time extension, re-use, repair, remanufacturing, recycling of products and materials

DyeCoo: waterless dyeing

Launch of the first commercial dyeing machine that uses supercritical carbon dioxide instead of water

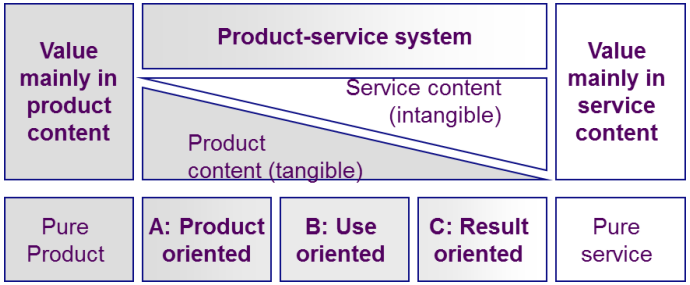
Production machine



High strength steel for lower weight cars

Changes to circularity – new business models?

- **Circular business models and consumer behavior**
  - Needs new business models: based on value creation, not product sales
  - Needs new business competencies, cultures, strategies
  - Particularly in B2C consumer acceptance of new business models is key



Light: Pay-per-lux

Copiers: pay-per-print, design for component re-use

Cars: sharing

Some examples that worked….

- Douwe Egberts Coffee Services
  - Avoids fights on dirty kitchens etc.
  - Easy for management
  - Puts DE in power node

DE was a coffee maker, not a machine builder nor machine leasing company…but they improved greatly their power in the value chain of coffee provision

- Chemical management services
  - Incentives low use of chemicals
  - ..but does not work in Germany, where firms want to keep control on hazards themselves

- Catering and cleaning services for offices

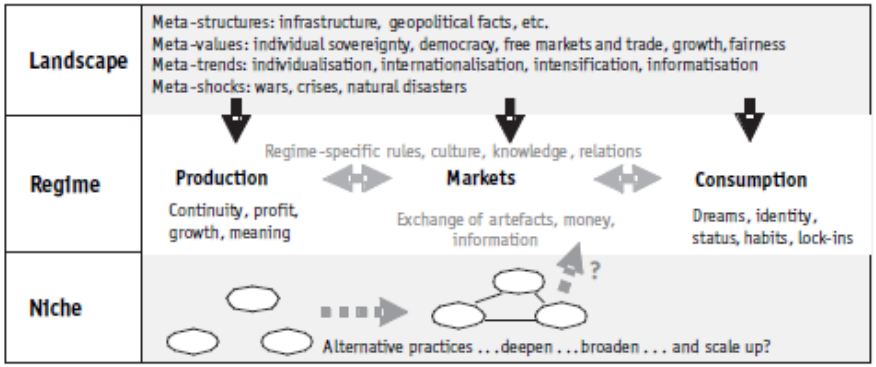
Some examples that saw problems

ABB and 'power by the hour'	• Electricity efficient motors, but expensive -> result oriented service • Sales people sold on volume, not expecting rising energy price • Result: ABB had multi-year contracts with losses
Ahrend and office furniture PSS	• Leasing and re-furbishing may be interesting • 'But hey, look – we have a production plant. We went back from 3 to 2 shifts, and cannot afford ourselves going back to 1"
British Airways outsourcing catering	• Caterer squeezed out personnel, that went on strike • BA could not influence this situation • In 2007, BA had to fly for weeks without meals
Performance contracts with the Police	…difficult if performance quality has important intangible aspects… …in some countries you see police agents fining pedestrians walking through red lights by the end of month, to 'make their target'
Complex DBFO contract systems	…Design-Build-Finance-Operate: high transaction costs & higher risks – if you operate a swimming pool, can you kick out annoying youth?

Governance, policy, regulation & transitions

Changes to circularity – what policies?

- Economic systems are inert
  - 'Regime': sunk costs and interests of existing players in the value chain
  - 'Landscape': a myriad of 'taken for granted' frameworks, like free markets and individual choice
  - 'Niches' or new models often immature
- Often, policy must bring change
  - Regulation: bans on landfill, certification of sustainable production of e.g. coffee
  - Tax adjustment: from labor to resources
  - Room for experiments: learning how new systems work
- Policy: in my view the key challenge



Example: history of circularity in the Netherlands

- **1970's – few laws and policies, no enforcement**
  - Landfill was cheap, Illegal dumping cheapest
  - Investment in hazardous waste incineration not profitable
  - Many scandals on dumping chemical waste and ground and water pollution
- **1980s – waste laws, start of planning and enforcement**
  - Quality standards for waste technologies and landfill
  - State support for building hazardous waste incineration (too risky for industry)
  - Enforcement program started and Waste plans with capacity regulation started (ensured investments in waste management were profitable)
- **1990s – strategic waste programs**
  - Identification of priority wastes (e.g. building and construction, electronics, packaging)
  - Targets for reduction and re-use set by government, backed by parliament
  - Roundtables with industry on HOW to realise these targets -> support policies per waste stream (e.g. deposit system for cars, electronics)
  - General measure: high landfill tax -> stimulated recycling
- **Result: Netherlands is best in class in Europe in re-use and recycling – via a mix of regulation, taxation and interactive policy**
- **We must now make the step from good waste management to circularity**

Conclusions – building a circular economy

Conclusions

Circularity

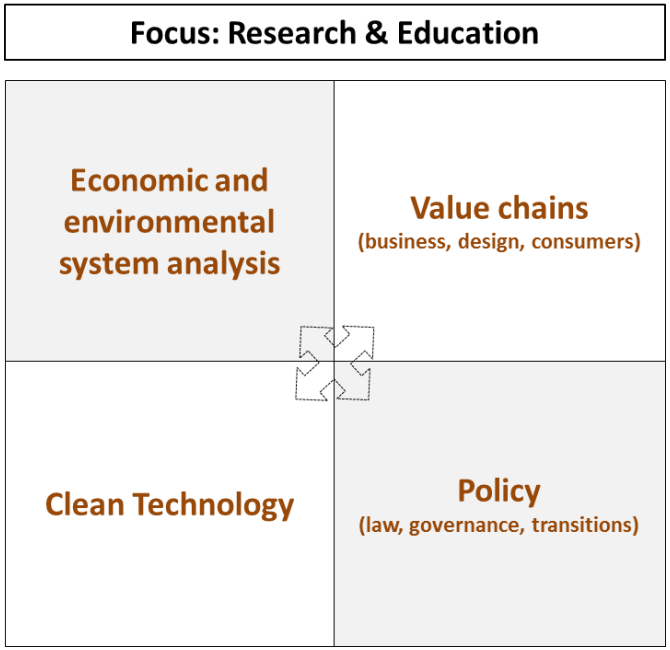
- Long-term must to avoid resource fights
- Must start now to avoid lock in

Clear role for business

- New technological solutions
- New business models

But policy cannot sit idle

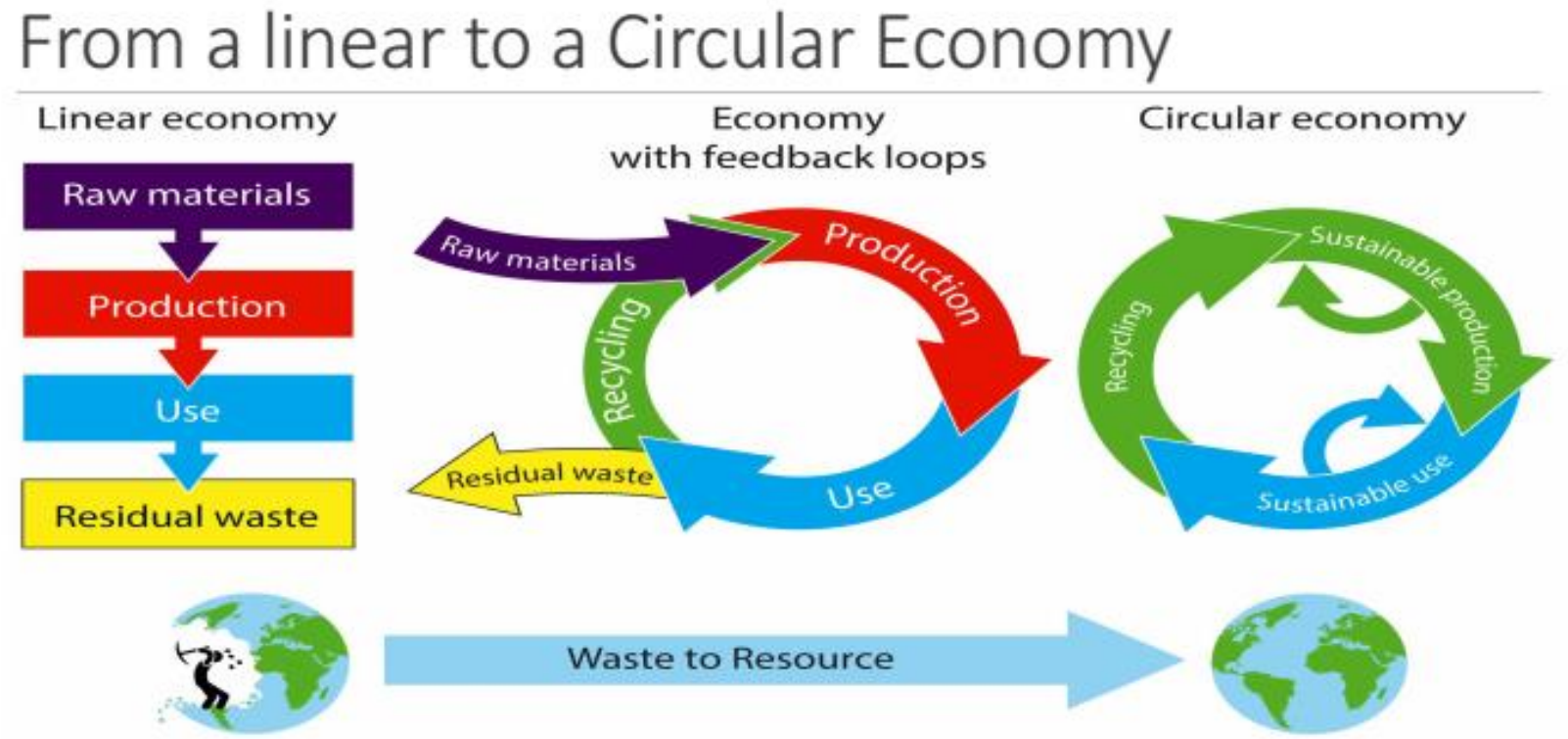
- Always think in four areas (systems, technology, value chains, governance)
- Develop smart policies based on bottom-up initiatives, market adjustments, rules



Thanks for your attention!

Reserve slides

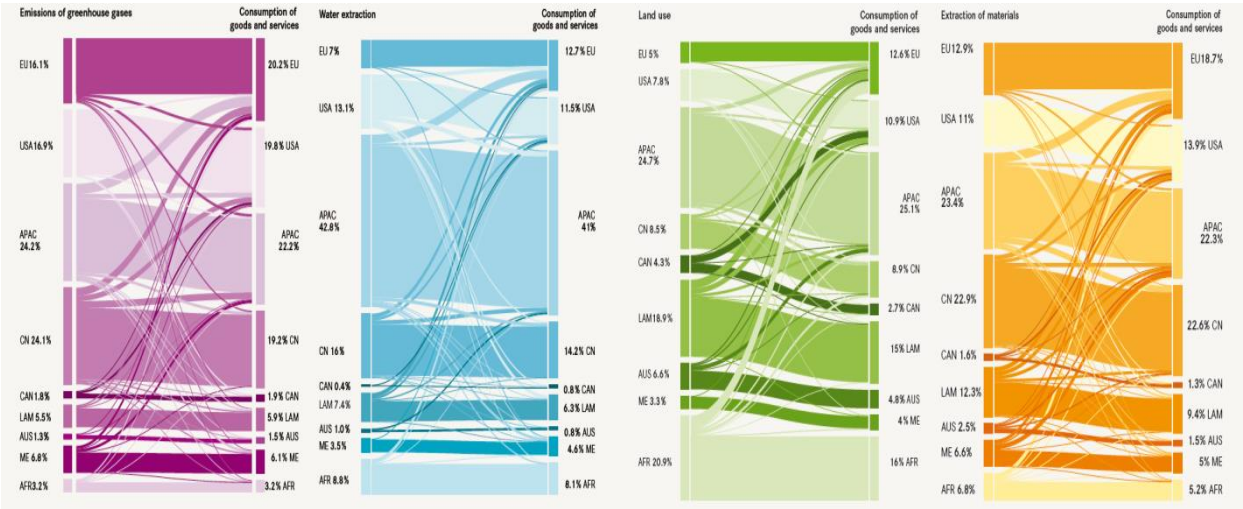
Or, differently shown:



Fact 3: Both Europe as Asia are vulnerable with regard to resource competition'…

- Asia
  - China alone uses e.g. already 50% of steel and cement in the world
  - Particularly India and Indonesia still must grow to reach Western wealth levels
- Europe
  - On ALL indicators: more resources needed for consumption as we produce
  - We now still make more money and can pay for it…but Asia is becoming smart and competitive too, and fast!

Carbon Water Land Materials



Left: resources/emissions produced

Right: resources/emissions needed for consumption

Thanks for your attention and regards from my staff doing LATAM-related research!

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Milagros Barceló
PhD Candidate

Daniel Arenas
Post-doc

Sofia Gomes
PhD Candidate

Amie Corbiin
PhD Candidate

Arnold Tukker
Professor &
director

Potential for collaboration between the Netherlands and Latin America on circularity

Applied research and business collaboration

- **‘Circular hotspot’ initiative of the Netherlands**
  - Platform for Dutch businesses that excel in circularity
  - That aim to collaborate internationally
  - Recent Foro Economía Circular in Bogota with contributions from Dutch Government and others
  - Dutch Embassy is very supportive in this

- **Aruba and TNO’s Aruba office**
  - Aruba wants to become a sustainable, carbon-neutral island
  - Dutch research organisation TNO supports this and has an office there with LATAM nationals

Research collaboration

LATAM, China and Indonesia are priority regions for Leiden University

Already good joint PhD programs with China and Indonesia – stipend PhDs from LATAM very welcome!

Example – EU Marie Curie Innovative Training Network on circularity with

- 15 PhDs
- Supervision & training – 6 international school periods
- 4 years (2016-2020)

With no less as 5 Hispanic PhDs – your future Green Growth leaders?

Leiden University Latin American & Caribbean Centre

3rd meeting Leiden-GRULAC
Visit to Faculty of Science by H.E. Ambassadors from Latin America and Caribbean countries
May 15th 2017

Gorlaeus Laboratoria, Einsteinweg 55, 2333CC Leiden

- Patricia Garcia-Martin (Aston/Spain),
- Beatriz Pozo Arcos (Linköping/Spain),
- Glenn Aguilar (Leiden/Costa Rica),
- Juana Camacho Otero (NTNU/Colombia)
- Carlos Siguenza Sanchez (Leiden/Mexico)

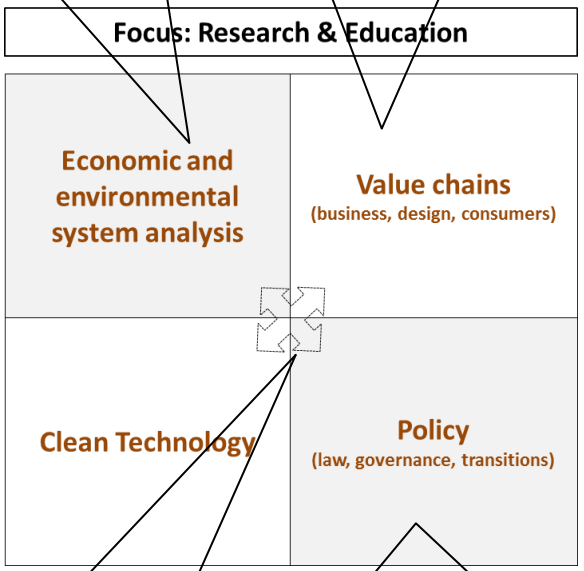
..what is what CfS and I try

- **My own history**
  - Ministry of Environment (1988-1990)
  - TNO (1990-2013)
    - Many different topics on innovation, policy, environment, indicators
    - PhD with prof. Jacqueline Cramer, '98
  - Leiden Univesrity, CML (2013-now)

- **Leiden-Delft-Erasmus CfS on circularity**
  - Technology (TUD)
  - Value chains (TUD-IO, EUR-RSM)
  - Governance (All)
  - Systemic economic & environmental analyses (UL-CML, EUR-Ec.)
  - *Education: Industrial Ecology, Sustainable Design, Technology, Business, and in future : Governance of Sustainability*

15 Mio Euro in major EU projects on global economic-environmental databases, with Eurostat, UN SD, OECD, EEA

3 Mio Euro in major EU projects on sustainable consumption and business models. Member EIT KIC Raw Materials



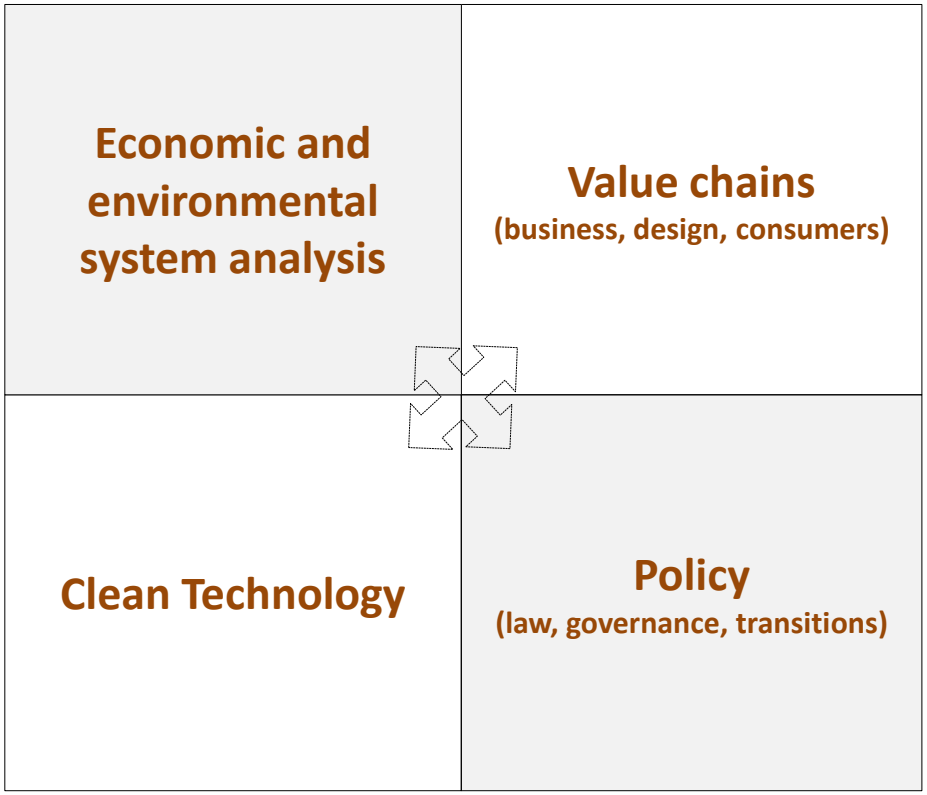
EU funded Marie Curie Training Network, 15 PhDs, 4 Mio Euro, 2016-2020 covering most of these fields

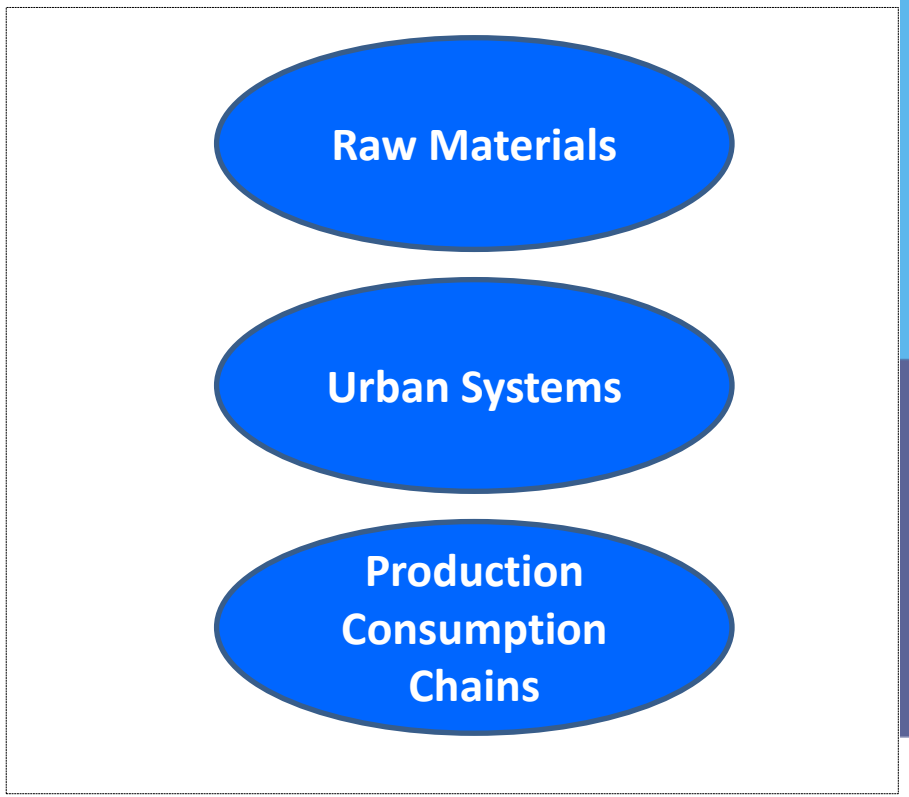
Dozens of TNO policy studies, study on circular product policy for the Dutch EU presidency

Leiden-Delft-Erasmus for Sustainability - focus on Education, Research and Valorisation

Focus: Research & Education

Application: Knowledge & Innovation





With no less as 5 Hispanic PhD students

- Patricia Garcia-Martin (Aston/Spain),
- Beatriz Pozo Arcos (Linköping/Spain),
- Glenn Aguilar (Leiden/Costa Rica),
- Juana Camacho Otero (NTNU/Colombia)
- Carlos Siguenza Sanchez (Leiden/Mexico)

- …the future Green Growth leaders for your region?

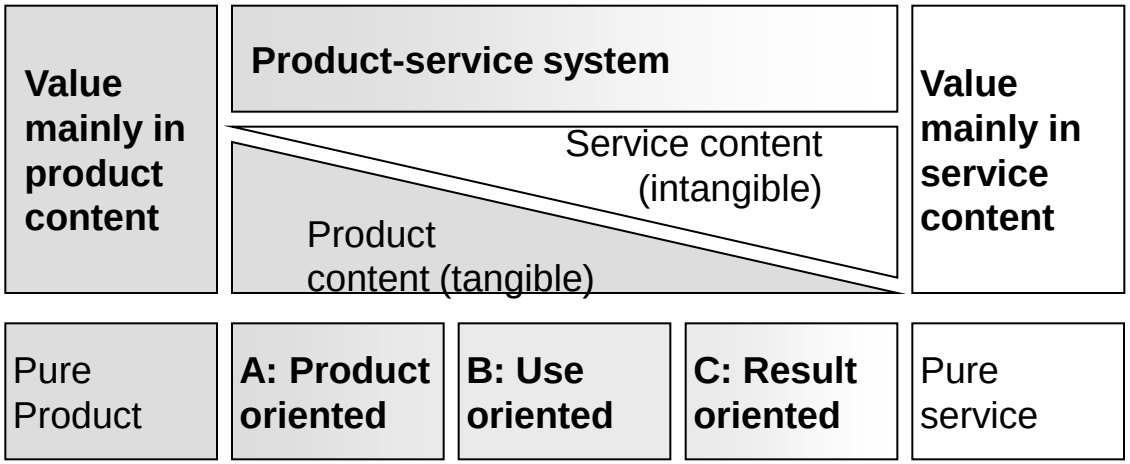
A Leiden Exemplar: Rudolph Pabus Cleveringa

- **Professor of Law at Leiden University, 1927-1958**

- **Lecture on 26 November 1940, WWII**
  - The Germans planned to fire all Jewish professors, including his mentor, promotor and colleague prof. Eduard M. Meijers
  - Cleveringa took over the class of Meijers making a now famous protest speech
  - Cleveringa was put in jail for 6 months and later taken hostage but like Meijers survived
  - US Medal of Freedom, voted ‘Greatest Leiden University Person’
  - Seen as the exemplar of ‘Preasidium libertatis’

- **How Leiden University honors him**
  - Annual lecture & Cleveringa Chair
  - Lectures by Leiden professors abroad

Product Service Systems: a classification



Car sales….

+ financing and maintenance

Car sharing system

Chemical management services

Some examples that worked….

- Douwe Egberts Coffee Services
  - Avoids fights on dirty kitchens etc.
  - Easy for management
  - Puts DE in power node

DE was a coffee maker, not a machine builder nor machine leasing company…but they improved greatly their power in the value chain of coffee provision

- Chemical management services
  - Incentives low use of chemicals
  - ..but does not work in Germany, where firms want to keep control on hazards themselves

- Catering and cleaning services for offices

Some examples that saw problems

ABB and 'power by the hour'	• Electricity efficient motors, but expensive -> result oriented service • Sales people sold on volume, not expecting rising energy price • Result: ABB had multi-year contracts with losses
Ahrend and office furniture PSS	• Leasing and re-furbishing may be interesting • 'But hey, look – we have a production plant. We went back from 3 to 2 shifts, and cannot afford ourselves going back to 1"
British Airways outsourcing catering	• Caterer squeezed out personnel, that went on strike • BA could not influence this situation • In 2007, BA had to fly for weeks without meals
Performance contracts with Police 	…difficult if performance quality has important intangible aspects… …in some countries you see police agents fining pedestrians walking through red lights by the end of month, to 'make their target'
Complex DBFO contract syst 	…Design-Build-Finance-Operate: high transaction costs & higher risks – if you operate a swimming pool, can you kick out annoying youth?

Drivers for PSS – it's the business case (**or not**)

BUSINESS

- **Value**: Co-creating user value versus market risk
  - Tangible value
  - **Intangible value**
- **Costs**: Minimizing system costs versus financial risk
  - Use of resources
  - **Transaction costs**
  - **Capital costs, risk profile, and ambiguity of the offering**
- **Power and dynamics**: Other benefits versus investment and capability risk
  - Power in the value chain / potential to capture value
  - Speed of innovation, learning, and option value
  - **Investment in new core capabilities, cannibalisation and loss of synergies**

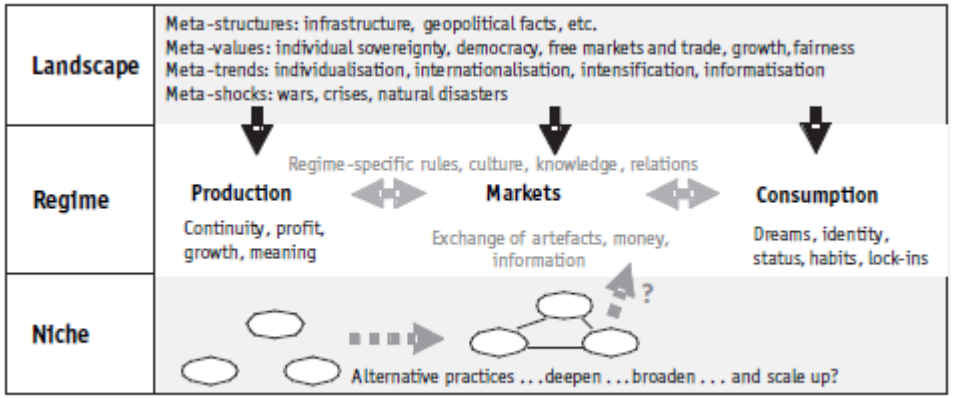
ENVIRONMENTAL:

- Product oriented = marginal,
- Use-oriented = Factor 2,
- Function oriented = Factor X

Tukker, A (2004): Eight types of Product Services – Eight Ways to Sustainability? Business Strategy and Environment

Changes to circularity – institutional boundaries

- **Governance, policy, regulation & transitions**
  - Production-consumption systems are inert
    - ‘Regime’: sunk costs, sunk habits and relations in the value chain
    - ‘Landscape’: a myriad of ‘taken for granted’ frameworks, like free markets and individual choice
    - New practices (e.g. PSS) stay often in niches
  - We need concepts that can make systems more fluid and sustainable



Changes to circularity – what governance?

- **Governance: some key approaches**
  - Markets (tax labor->resources)?
    - Price signal solve things
    - Legitimacy for such measures
  - Top-down government?
    - Planning possible, determined systems
    - Legitimacy for such measures
  - Bottom up actions from the Energetic society?
    - EMF, WBCSD, entrepeneurs
    - High profile actions aimed at changing mindsets: Dutch Urgenda
  - Stalemate and waiting for disaster?