Climate change risks and the measurement of circular economy

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Topics for discussion

- Why circular economy a thermodynamic model
- Measuring circular economy – complex indicators
- Conclusions

Why circular economy a thermodynamic model

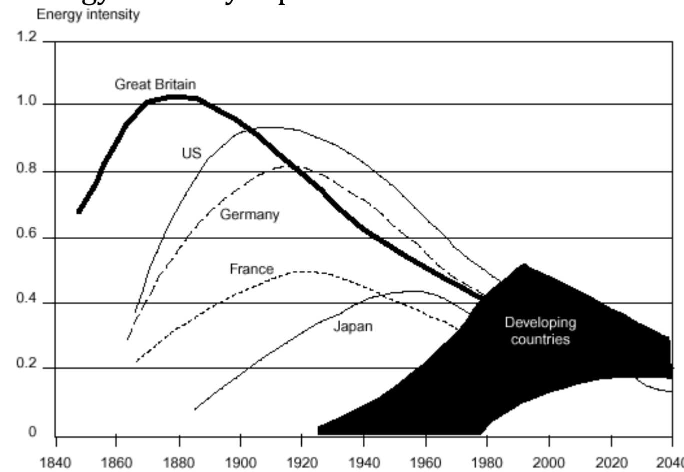
- The energy intensity evolution shows periods of increase when the economy is reorganizing followed by decrease as a more efficient structure is in place.
- In first stage energy is consumed not only to produce GDP but to change structure – this diminishes entropy
- In second stage less energy is consumed per unit of GDP.
- In both stages resources are exchanged with the environment

Why circular economy a thermodynamic model

$dST/dt+dU/dt+Sk_i dm_i/dt=0$

where: k_i – a constant of each resource i measured in energy per unit of resource; it describes the technologies available for using the said resource;
m_i – the quantity of resource i exchanged

Energy intensity reported to the British Parliament



Estimated temperature increase for selected economies [°C]

	dU	dS	T=dU/-dS
USA	-164.17	79.54	2.06
UK	-128.20	114.58	1.11
Germany	-64.10	102.27	0.62
Japan	-48.19	48.19	1.00
Italy	-21.97	40.81	0.53

Why circular economy a thermodynamic model

- To diminish the temperature increase one needs to reduce the new denominator ($dU/dt + Sk_i dm_i/dt$).
- This is done by e.g. reducing the velocity of transfer of primary resources by increasing product use time i.e. $-dm/dt$.. In economic terms this would mean e.g. to make more durable products with more possibilities to increase their use time by a better maintenance capability in their design and by a better type of service in operation.
- Also, the recycling of waste may contribute to diminishing the rate of transfer of primary resources from/to the environment. Making steel from scrap metal rather than from ore has an impact both on less primary resource transfer and on the smaller overall consumption of energy for metallurgical production.
- Renewable energy is also contributing to diminish the exchange od resources
- CIRCULAR ECONOMY IS A MUST.

Measuring circular economy – complex indicators

Table 5.1 Macro level circular economy indicators (Geng et al., 2012)

Category	Indicators used
1. Resource output rate	Output of main mineral resource, output of energy.
2. Resource consumption rate	Energy consumption per unit of GDP, energy consumption per added industrial value, energy consumption per unit of product in key industrial sectors, water withdrawal per unit of GDP, water withdrawal per added industrial value, water consumption per unit product in key industrial sectors, coefficient of irrigation water utilisation.
3. Integrated resource utilisation rate	Recycling rate of industrial solid waste, industrial water reuse ratio, recycling rate of reclaimed municipal waste water, safe treatment rate of domestic solid wastes, recycling rate of iron scrap, recycling rate of nonferrous metal, recycling rate of waste paper, recycling rate of plastic, recycling rate of rubber.
4. Waste disposal and pollutant emissions	Total amount of industrial solid waste for final disposal, total amount of industrial wastewater discharge, total amount of sulphur dioxide emissions, total amount of COD discharge.

Measuring circular economy – complex indicators

Table 6.1 Broad classifications of current indicators potentially relevant to the circular economy

Indicator type	Examples	Availability of data	Relevance to the CE
Sustainable development	Social economic development, sustainable consumption and production, social inclusion, demographic changes, public health, climate change and energy, sustainable transport, natural resources, global partnership, good governance (Table A2)	Voluntary based reporting via EU Directorate-General for Energy (focused), European Sustainable Development Network (ESDN); corporate sustainability indicators (e.g. carbon disclosure)	Natural resources, sustainable consumption and production
Environmental	Agriculture, air pollution, biodiversity, climate change, energy, fisheries, land and soils, transport, waste, water	Regulatory based reporting via EEA cores indicators and country-specific statistics	Waste generated, packaging waste generation and recycling
Material flow	Domestic extraction, direct material consumption, domestic material input, physical trade balance, net additions to stock, domestic processed output, total material requirement, total domestic output	Eurostat, SERI	All
Societal behaviour	Sharing, municipal waste recycle, waste generated per capita (total and segregated), environmental/resource taxation	National and voluntary organisation statistics	All
Organisational behaviour	Material flow accounting in organisations, remanufacturing, use of recycled raw materials, eco-innovation, per capita statistics (e.g. reduction in waste generation per capita)	Private sector voluntary reporting via EU Forum for Manufacturing; ZVEI (German Electrical Industrial Association); VDMA (German Engineering Federation); etc.	All
Economy performance	Resource productivity, recycling industry, green jobs, waste generation/GDP, 'transformation of the economy'	Eurostat EU Resource Efficiency Scoreboard	All

Measuring circular economy – complex indicators

Box 1 An illustration of a potential composite indicator

One possible combination would be as follows:

- energy productivity (GDP/total primary energy supply) where larger values are associated with progress;
- GDP per capita (GDP/population): the present indicator for progress;
- the rate of resource recycling (recycle rate as a percentage): improved recycling would increase this indicator
- divide by the amount of carbon dioxide emissions, so reducing emissions would increase the indicator.

According to the formula

$$\frac{\text{GDP} \times \text{GDP} \times \text{recycle rate}}{\text{TPES} \times \text{population} \times CO_2 \text{ emission}}$$

Using data from IEA (2013) (except for the recycling rate), results in the following.

Country	Population	GDP (trillion US$)	TPES (toe per capita)*	CO_2 emissions (Mt CO_2)	Recycle rate (%)	Composite indicator value†
USA	314.3 M	14.232	6.8	5,074	37	2.2
Germany	81.9 M	2.851	3.8	755	45	19.01

*TPES, total primary energy supply; toe, tonnes of oil equivalent. †The composite indicator value is given as 10^8 US dollars per capita per tonne of oil equivalent of carbon dioxide.

Conclusions

- Circular economy is the main vehicle to diminish environmental temperature increase.
- The exchange of resources with the environment must be reduced by generating new technologies that transform present waste liabilities into assets.
- Financing circular economy actions may be done based on a climate change insurance policy resulting from risk evaluation stemming from big data analysis.
- Measuring circular economy needs new complex indicators that shed new light on development values.

Thank you !

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