ECO-REGION NW

Business paper 2:

MATERIAL FLOW APPLICATIONS TO BUSINESS SUSTAINABILITY ANALYSIS

draft paper for discussion
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Environmental sustainability in business

The challenge

Environmental sustainability is generally identified with fixed limits defined by local or global thresholds, in environmental capacity / risk / irreversible change.

Meanwhile businesses are generally identified as small parts of a much bigger picture: as part of a economy: as part of a product supply chain: as part of a system which delivers human welfare. It is generally very difficult to translate the macro-level thresholds (e.g. climate change emissions) to specific targets for business in any sector, as they are all to some degree inter-dependent.

It is also clear that often the major effects of business are not direct material flows, but 'induced' effects elsewhere in the supply chain. Clearly a supplier of concrete blocks might accept some responsibility for the emissions of a cement factory. But how many estate agents or interior designers will accept responsibility for the same cement factory, even while they are both integral parts of the construction industry? Many businesses will naturally argue for their interest in externalizing the externalities. This becomes more significant the more an economy shifts from a material basis towards a service or information basis. It is also significant in terms of the emerging CSR agenda, where businesses are being pressured into new linkages of social / environmental responsibility.

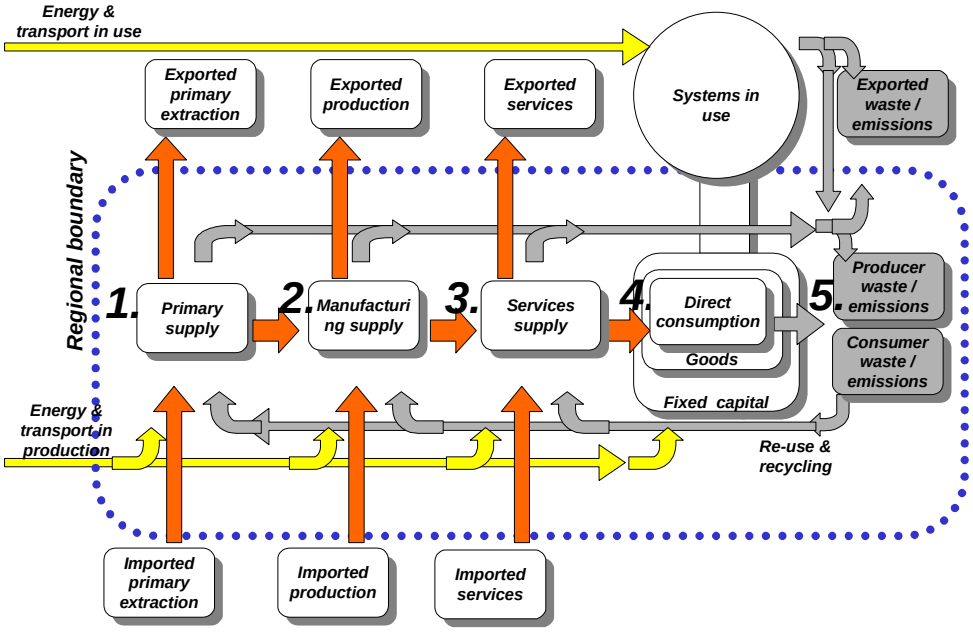
The resource flow approach has much to offer this question, particularly in its 'next generation' form where inter-industry flows are represented through the input-output method. The REAP system in development is seen as a key reference point in identifying sustainability thresholds in business sectors. These then provide an 'envelope' or benchmarking frame for application to specific businesses, processes or products.

The purpose of these notes is to set out the analytic framework, and provide directions for further development in the business benchmarking function of REAP.

What is environmental sustainability in business?

To explore this question we use the MFA framework mapping as illustrated below.

MFA FRAMEWORK



This shows the general pattern of the flows of material through the economy, arranged approximately in the order of economic classifications such as SIC / NACE:

- Primary extraction on the left: this shows the resource-intensive industries where materials enter the economy from natural sources
- Secondary manufacturing is where these materials are processed into products
- Tertiary services represents the less material-intensive sectors where further value is added through distribution or information.
- Final demand represents the public or private consumers of the products / materials. However there are different types of consumption as defined in material flow terms (with parallels in accountancy terms):
- Direct consumption, e.g. food or drink which passes through the body within 1 day, or services at specific times and places.
- Goods consumption, e.g. 1-3 years lifetime, such as clothes, books, household products
- Capital consumption, e.g. fixed assets of more than 3 / 5 years duration: e.g. buildings & infrastructure.

At each of these stages there are other key factors in material flow:

- Imports from outside the regional boundary (however this is drawn)
- Exports to outside the region
- Supply of resource 'factors' i.e. environmental services, in particular transport and energy (construction could be added to this)
- Output of waste and emissions, within or outside the region
- Re-use and recycling loops going back up the chain.

Finally it is clear that for many activities, the operation / activity of the product in use can be more significant than the supply of the product itself. The 'systems in use' category (in the round bubble) shows the direct supply of energy /transport, and the direct emissions / waste:

- Local emissions / waste, within the regional boundary
- Global emissions / waste, outside the regional boundary.

Resource flow sub-models

From the chart above we can identify several types of sub-models, each of which may be relevant and data-available for different kinds of activity or business.

- Demand intensity sub-model
- Supply chain sub-model - drawn from PRODCOM data by main upstream sectors listed below
- Consumption sub-model – details of consumption types, e.g. food types
- Physical stock – flow sub-model: focusing on issues where total stocks, changes and conditions are the issue, e.g. housing stocks.
- Operations sub-model: focusing on the performance in use, e.g. energy efficiency of buildings or transport

The table below here shows how each of the 'key activities' uses a different combination of sub-model types.

	KEY TO ACTIVITY SECTOR MODEL TYPES								
		1	2	3	4	5	6	7
		food etc	***shelter***	***energy***	***mobility***	***goods***	***consumer services***	***public services***
	QUESTIONS	include non-food agricultture?	include civil engineering?	include water , telecoms etc?				
IO final demand side	**ACTIVITY INTENSITY**							
	economic activity intensity - activity units / economic units (units / £)	As total tonnage of food is static - intensity could relate to 'added value'???	overall demand for houses / other space	*(final energy demand given from other sectors)*	overall demand for pass / freight travel	overall demand for physical goods	demand for all other services in economic units	overall demand for health & education in employment units???
activity model	**SUPPLY CHAIN MODEL** (units may vary)							
	drawn from PRODCOM data by main upstream sectors listed below (t)	general supply chain with imports & exports	= production of building materials from quarry to landfill	= primary / secondary / final energy chain	freight trans - feedback to production coeff.			
activity model	**CONSUMPTION MODEL**							
	details of types of direct consumption (t)	basic food / drink types				household appliances, goods & chattels	types of commercial services	
activity model	**PHYSICAL STOCK MODEL**							
	stock flow account for fixed capital & infrastructure items (t)		stock - flow of houses / other buildings		*stock of vehicles & roads???*	stock - flow of appliances etc		stock-flow of education & health places
activity model	**OPERATIONS MODEL**							
	performance in use data e.g. energy in use, material throughput (GJ)		= energy efficiency of houses / other	emissions factors & energy technology	energy / emissions by transport modes	energy efficiency of appliances etc	energy / material demand of commercial sector	energy / material demand of public sector
IO sectors upstream	**SUPPLY SECTORS**							
	key economic sectors which supply the activity from upstream	agri, forestry, fishing etc	quarrying, materials production	fossil fuel extraction, power distribution	transport engineering & fuel supply	key manufacturing sectors		
IO sectors downstream	**USE SECTORS**							
	key economic sectors which use the activity from downstream	catering, education, health, retail, HH	real estate, many office / industrial, HH	purchasers of energy incl HH	retail, distribution, transport services, HH	retail, distribution, transport services, HH	government, HH	HH

Limitations of the framework

The simplified framework above can be seen to represent an ideal theoretical case, where one firm uses one material to make one product with one worker, with one type of social outcome. In reality, of course, each of these domains can be vastly complicated by supply chains, institutional effects, market effects, global / local externalities and so on. In many western countries many key 'products' are assembled on a global basis from hundreds / thousands of rapidly changing supply chains, each with their own complex set of interactions.

e.g. The World is Flat: Brief History of the Globalized World in the 21st Century, by Thomas Friedman (Allen Lane).

> Dell uses multiple suppliers for most of the 30 key components that go into its notebooks. That way, if one supplier breaks down or cannot meet a surge in demand, Dell is not left in the lurch. So here are the key suppliers for my Inspiron 600m notebook: the Intel microprocessor came from an Intel factory either in the Philippines, Costa Rica, Malaysia or China. The memory came from a Korean-owned factory in Korea (Samsung), a Taiwanese-owned factory in Taiwan (Nanya), a German-owned factory in Germany (Infineon), or a Japanese-owned factory in Japan (Elpida). My graphics card was shipped from either a Taiwanese-owned factory in China (MSI) or a Chinese-run factory in China (Foxconn). The cooling fan came from a Taiwanese-owned factory in Taiwan (CCI or Auras). The motherboard came from either a Korean-owned factory in Shanghai (Samsung), a Taiwanese-owned factory in Shanghai (Quanta), or a Taiwanese-owned factory in Taiwan (Compal or Wistron). The keyboard came from either a Japanese-owned company in Tianjin, China (Alps), a Taiwanese-owned factory in Shenzen, China (Sunrex), or a Taiwanese-owned factory in Suzhou, China (Darfon). The LCD display was made in either South Korea (Samsung or LG Philips LCD), Japan (Toshiba or Sharp), or Taiwan (Chi Mei Optoelectronics, Hannstar Display, or AU Optronics). The wireless card came from either an American-owned factory in China (Agere) or Malaysia (Arrow), or a Taiwanese-owned factory in Taiwan (Askey or Gemtek) or China (USI). The modem was made by either a Taiwanese-owned company in China (Asustek or Liteon) or a Chinese-run company in China (Foxconn). The battery came from an American-owned factory in Malaysia (Motorola), a Japanese-owned factory in Mexico or Malaysia or China (Sanyo), or a South Korean or Taiwanese factory in either of those two countries (SDI or Simplo). The hard-disk drive was made by an American-owned factory in Singapore (Seagate), a Japanese-owned company in Thailand (Hitachi or Fujitsu), or a Japanese-owned factory in the Philippines (Toshiba). The CD/DVD drive came from a South Korean-owned company with factories in Indonesia and the Philippines (Samsung); a Japanese-owned factory in China or Malaysia (NEC); a Japanese-owned factory in Indonesia, China, or Malaysia (Teac); or a Japanese-owned factory in China (Sony).

Application to business benchmarking

This is then the context for business benchmarking, and its applications in environmental management, performance monitoring, or resource productivity metrics in various ways. First we look at the generic typologies in which any business may engage with resource flows, and hence resource productivity.

Benchmarking framework

The overall framework contains three types of influence:

- Direct
- Indirect
- Induced

These can be applied to three different stages in the resource flow cycle:

- Production
- Consumption
- Operation

For each of these there are 3 generic criteria of non/sustainability, where this can be drawn from scientific evidence, social welfare or political priorities:

- Capitals / assets / resource depletion
- Capacities / impacts
- Risk / hazard / equity

The eco-footprint is one universal measure which represents to some degree the first two of these. In theory this (suspiciously symmetrical) scheme could be visualized in terms of a rubik's cube. However there may be a case for introducing an 'environmental fate' 4th category to represent the end of life impacts of products, where this is significant.
It is also significant that there are degrees of certainty or contention associated with each of these categories:

- Direct – in principle this would be measurable in terms of what physically leaves or enters the 'factory gate'
- Indirect – in principle this is calculable through the IO method and its spin-offs
- Induced – this is more debatable as to what is an induced effect. For instance how many estate agents will accept responsibility for the cement factory? Many businesses will naturally argue for their interest in externalizing the externalities.

Types of influences: production

1) Direct production impacts: direct or on site consumption of energy / resources, in the processing and manufacture of physical products. This applies more to material- or product-intensive businesses in manufacturing sectors, for instance the manufacture of plastic containers.

2) Indirect production impacts: embedded energy / resources in the upstream or downstream stages of the supply chain. This applies more to processes at one stage in a more lengthy and complex supply chain, for instance the impacts of manufacturing above may be outweighed by the production of the plastic itself.

3) Induced production impacts: embedded energy / resources where the material flows are removed 'laterally' at some distance from the supply chain. This applies to producer services or consumer services, for instance an environmental consultancy which advises on the manufacturing process above.

Types of influences: consumption

A similar breakdown can be identified on the consumer side, for both households and the public or non-profit sectors, i.e. direct, indirect and induced impacts. Such a typology can then be applied to the question of resource productivity, with the added dimension of what is here titled 'resource flow proximity', i.e. the distance from the main resource flow path in terms of number of supply chain links. A structural path analysis can help to identify in broad sectors the most significant of these.

1) Direct consumption impacts: this is a measure of direct physical inputs required to deliver a product or service. E.g. the tonnes of concrete used in a housebuilding project for a consumer.

2) Indirect consumption impacts: a measure of indirect physical inputs: e.g. the IO analysis of inter-industry trading involved in delivering the tonnes of concrete to the house building project. This can be assessed through the REAP IO tables, as far as the product can be defined in material terms.

3) Induced consumption impacts: assessment of what other activities are 'induced' or influenced in a causal link by the consumption. A good example is in tourism which involves not only flows of material and energy, but induced changes in urban and economic development all around it. These of course may be difficult to measure and contentious to the business.

Types of influence: operation

A similar breakdown can then be drawn for the operation / activity of products in use. This applies to almost every material product, but is more significant particularly with industrial products which are machines designed as energy processors, i.e. cars, appliances, computers: or as service products which are designed as logistics systems, e.g. tourism or catering which require transport.

1) Direct operational impacts: these are direct flows of energy and emissions through the physical product or physical system. E.g. the energy consumed by a car through its lifetime.

2) Indirect operational impacts: this calculates the total indirect energy /emissions caused by operation of the car, including for instance the energy involved in producing the fuel, maintenance cycle etc

3) Induced operational impacts: again this is a wider category where the boundaries need to be negotiated and tested. For instance the car is part of a vehicular system which then induces the demand / supply of associated infrastructure such as roads, landuse, traffic lights & emergency services.

Upstream – downstream links

To provide further focus the upstream – downstream analysis is useful for identifying the nature of the causal chains, and definition of direct / indirect / induced influences.

This works generally within the input-output methodology for inter-industry transactions, and the conceptualization of upstream / backward linkages, and downstream / forward linkages (Isard 1989: Giljum & Hubacek 2003).

- Upstream / backward links: in economic terms, suppliers to the industry: in physical terms, precursor materials / products.
- Downstream / forward links; in economic terms, purchasers or users of the industry output: in physical terms, successor materials / products.

The definition of downstream / upstream depends on the position in the centre, i.e. the sectoral profile. While this appears obvious, for many businesses covering a range of activities the sector classification is not always apparent.

Some clue may be given by the product classification as below.

Table 1: business benchmarking: upstream / downstream analysis

	Externality / factor inputs	Backward linkages	Activity	Forward linkages	Externality 'goods'	Externality 'bads'	
Product / operation MFA			Product operation	Users of product operation	Welfare from product operation	Operational waste, emissions	
Direct MFA	Energy, transport	Primary materials & components	Product manufacture	Assembly, distribution, retail	Products & by-products	Production waste, emissions	
Indirect MFA	Inter-industry energy / transport	Inter-industry demands		Value added services			
Induced MFA	Inter-industry resource demands	Inter-industry services	Inter-industry value added	Consumption	Welfare from consumption	Post consumer waste etc	

To provide the analytic detail on these layers of influence, the structural path analysis approach can be a useful tool.

Material intensities

Finally there is a significance in the material intensity, which indicates how much of the economic value is in the materials, how much in other

Table 2 Material intensities in the business supply chain

	Primary	Secondary	Tertiary	Direct consumption	Indirect consumption	Direct emissions	Indirect impacts
MFA	Materials enter economy	Added value to make products	Added value in services	Materials consumed directly in products & services	Materials consumed indirectly as part of system / infrastructure		
MFA intensity	Material intensive	Product intensive	Service intensive	Consumption intensive			
Thresholds & limits	Resource / capacity depletion			Demand side	Infrastructure side	Pollution thresholds	Eco-system change
Ideal supply chain	Material extracted	Single product	Simple sales	One type of consumer		Emissions & waste	Minor outcomes
Average business	Many materials	Range of products	Range of services	Range of customers			
Multi national business		Many complex products	Many logistics & services				

Sectoral template

- To help communicate the above information in a common structure, a sectoral balance sheet is proposed, in the kind of format below.
- It is anticipated that this would be automatically generated for each of 76 sectors. The sheet contains not only model data but also a summary of 'issues' to be drawn by each industrial sector.
- The sheet itself will need to be summarized for reporting and communication, as in the benchmark concept below.

	SECTOR TEMPLATE / BALANCE SHEET						(b)										
			SECTOR	DIRECT IMPACTS			IN DIRECT IMPACTS			LINKAGES			PROJECTIONS		ISSUES	
source				impact	per £GVA	per employee	impact	per £GVA	per employee	main product	main suppliers	main purchasers	trends	targets	business issues	policy issues
				tonnes	t / £	t / job	tonnes	t / £	t / job				(direct)	(direct)	(text to be inserted by	
	SECTOR INFO															
		GVA														
		employees														
		import %														
		export %														
	GENERAL IMPACTS															
		energy demand														
		transport demand													cost, congestion	
		water demand													cost	resource
		land use														planning
	CLIMATE total CO2 eq.															
AEAT		CO2 (as C)														
AEAT		CH4														
AEAT		HFC														
AEAT		N2O														
AEAT		PFC														
AEAT		SF6														
	TOTAL PRIMARY INPUTS															
REAP		biomass														
REAP		minerals														
REAP		fossil fuels														
	TOTAL EF															
REAP		Energy (fossil fuels)														
REAP		Energy (nuclear)														
REAP		Crop land														
REAP		Pasture														
REAP		Built land														
REAP		Sea														
REAP		Forest														
	AIR EMISSIONS															
AEAT		SOX														
AEAT		NOX														
AEAT		CO														
AEAT		PM10														

Benchmarking indices

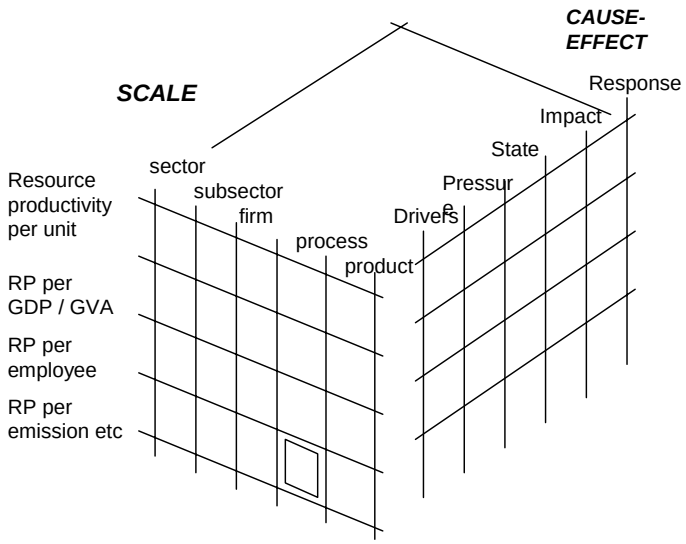
The concept of benchmarks is to set out a framework for the interaction of economic activity with environmental impact / resource consumption. This would contain, as per the 'cube' visualization below:

- Environmental factors in waste, materials, transport, energy, water, minerals, toxicity burden if known etc
- Economic / social factors: GDP / turnover, GVA, employees, capital investment, other EHS / corporate responsibility
- average / best practice for similar firms / products
- average / worst / best practice for the sector and sub-sector

- comparison with regional pressure points, limits, goals and targets

For many of these issues a close link to Environment Agency information systems on major processes would be essential.

ECO-REGION: BENCHMARK FRAMEWORK



An example of the benchmarking outputs is shown below from the Contour developmenmt programme.

Product benchmarking

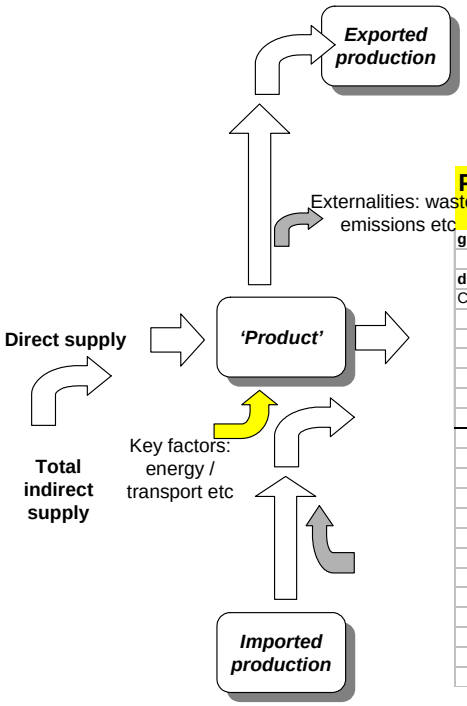
Further material to follow on this.

Generally, the environmental performance benchmark of a 'product' is a counterpart to that of a business which supplies it or uses it. However the data sources will be different and hence the calculation methods. One important question is the definition of a product, here proposed as a hierarchy:

- Composite items: e.g. house, car, computer
- Product components: brick, tyre, chip
- Product materials: clay, silicon

The general structure will resemble the following:

PRODUCT MFA report / interface



PRODUCT INTERFACE

general arrangement by COICOP then details by PRODCOM					
drill-down hierarchy					
COMPOSITE PRODUCTS				e.g. "house"	
	PRODUCT ITEMS			e.g. "bricks"	
		MATERIALS		e.g. "concrete"	
			BACKWARD	**ACTIVITY**	**FORWARD**
			INPUTS		**OUTPUTS**
		EXPORTS			export ratio
		ACTIVITY	intermediate use	output	intermediate suppl
			vector	stock change	vector
		IMPORTS	imports ratio	recycling ratio	
		MFA FACTORS	energy		waste
		per unit	transport		air emissions
		product / material	land		GHG emission

Application to regional MFA toolkit

For further detail on business benchmarking systems see the Eco-region NW working paper: *Potential role and impact of selected benchmarking systems on industry benchmarking function of the Eco-Region NW tool .* http://www.art.man.ac.uk/PLANNING/cure/PDF/IBS.pdf

Regional mass balance – benchmarking concept

The Eco-Region NW was designed with the aim of linking the regional mass balance / footprint scheme with the most effective of current business benchmarking systems.

Since its inception the Eco-region NW has been combined with the REAP system, and aims to provide a demonstration and application of the REAP system to business benchmarking. It focuses on an example sector, the construction industry to do this.

Precursor schemes:

ENWORKS:

- this is the most active scheme in the NW region, with NWDA sponsorship etc.
- It contains an on-line data capture tool which serves to gather all info together.
- This is focused on 'opportunities' which have been discussed in site visits, and has a good breakdown of concept, feasibility, implementation stages etc.
- Drawback – the analysis only counts energy, solid waste & water production

ASSESS project: nearing completion.

- This focuses on environmental policy, but also contains a trial application of direct 'mass balance' questions. Experience shows that these are difficult to translate for different business sectors, and difficult for business to find data for.
- Drawback – the final report doesn't tell business anything they didn't know already. Hence not very much incentive to do it.
- The breakdown of industrial sectors & material types is very basic.
- the mass balance questions are outputted to spreadsheet, and the project didn't include for any processing of this data.

PERFORM system

- Wide range of industries across the EU in comprehensive env benchmarking
- Used a core set of indicators with a sector-specific set
- Difficulties in persuading industries to supply the data, in spite of apparent incentives.

REAP system:

- this is now emerging as a new generation of materials / energy analysis.
- Enables cross –reference between production sectors & consumption types.

- arranged on the Env statistics 76 sector (SIC123) breakdown of production.
- Enables both direct effects and indirect effects to be seen, e.g. so that service sectors can realize their full indirect impacts.

Implications

The implication so far is that on-line questionnaire type survey forms work most effectively:

- with human contact as backup,
- where data collection is very easy,
- where there are strong incentives for data collection.

However On-line benchmarking – thought to be technically complex & costly, and prone to failures of one of the above.

Proposals

Develop a concept for business benchmarking which is

- Based on application of the REAP structure
- Can be directly linked to the ENWORKS or similar
- Builds on recent work on the Assess scheme. (not necessarily part of that scheme)

Given the drawbacks of on-line benchmarking above, it is now proposed to provide a ready made 'low-tech' spreadsheet template to be downloaded. This can be generated directly from the REAP system, with data simply extracted for that industrial sector.

This will contain pre-generated data for that sector, normalized by GVA, GDP and employee, including:

- Energy by fuel
- Transport by mode
- Waste & recycling
- Raw materials
- Exports & imports
- Typical product range
- Overall footprint as calculated in REAP, direct & indirect
- Where possible, best practice / best available technology for each of the above.

Businesses can then fill in as much of this as they can. Each item they fill in will generate intelligence on benchmarking of direct value to themselves. Items not filled in still have the default values for that sector.

(We need some incentive or reminder system for returning the forms…)

- This will be fed into existing schemes e.g. Enworks, who have the active outreach programmes on the ground
- It would also be fed into industrial / trade associations, who have the more detailed knowledge of opportunities in each sector.

Product consumption template

We would also aim to provide the specs for a similar downloadable template which covers a similar range of question for typical products. (probably to be implemented in a future project).

Incentives for business:

The proposed system needs to bring the push & pull factors up front, visually in the spreadsheet form / webpages. Push factors include:

- Cost increases
- Regulatory limits
- Negative image

Pull factors include:

- Cost savings
- New markets (including emissions trading).
- Positive image

For material / energy intensive or transport intensive businesses, there are regional limits as above.

Overall there will be a move towards transparency on CO2 & footprint reporting for all kinds of business. This tool should be of practical help in fostering transparency.