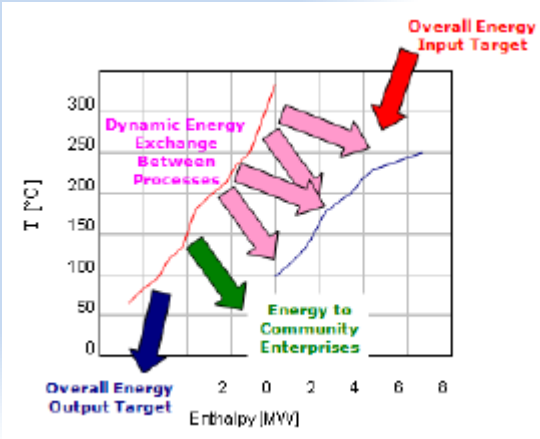
link energy Ltd
Business Improvements Through Creative Thinking

Re:Sourcing UK

SYMBIOSIS 2014
19th-21st June 2014

2nd and 3rd Generation Industrial Symbiosis - What would it Look Like?



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What will 2nd and 3rd Generation of Industrial Symbiosis Look Like?

An Introduction.....part of the journey?

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Re:Sourcing UK

Team Profile – Yorkshire&Humber

- Most established team ... Part of original pilot programme
- Credentials (*from 2005 → 2012*)
  - **1,500,000** tonnes waste diverted from landfill
  - **310** jobs created, **723** jobs saved
  - **1,200,000** tonnes virgin materials saved
  - **844,000** tonnes CO_2 saved
  - Facilitated investment of **£21.4m** in waste diversion / symbiosi
  - Saved businesses **£53m** costs

TOTAL

HUNTSMAN
Enriching lives through innovation

Young's

Ciba

Greenergy

TOYODA GOSEI

UK COAL

CEMEX
Building the future™

YorkshireWater

bp

SITA
SUEZ

Cherry Valley

Carlsberg

AIR LIQUIDE

inetec

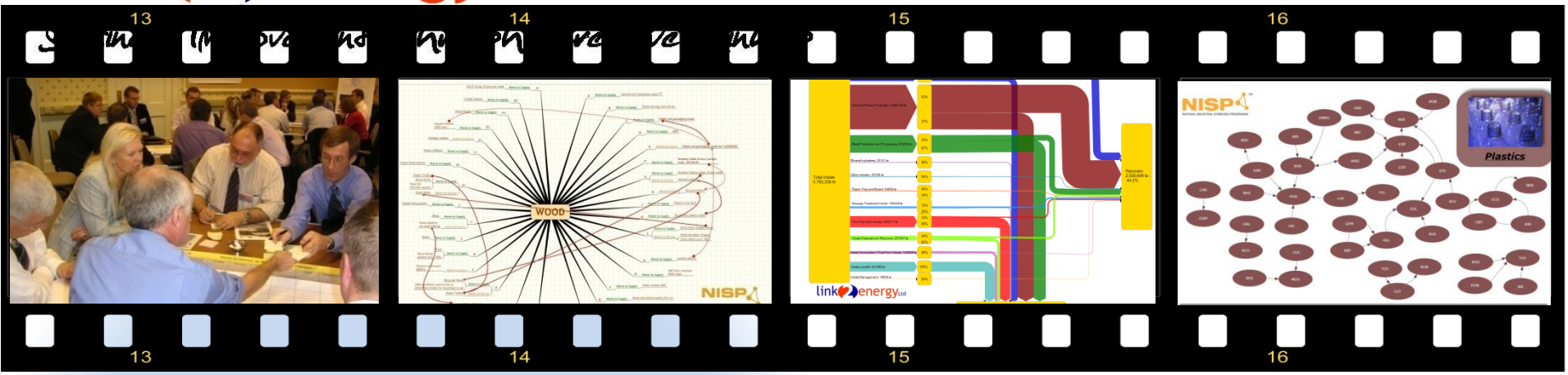
corus

syngenta
UK & IRELAND

ConocoPhillips
Energy for tomorrow

IKEA

Innovation Timeline



2004

Quick Win Workshops

Methodology developed in Yorkshire & Humber as pilot region

The key elements from this time are still very much in use across NISP network today.

2005

Mindmaps

Using mindmaps as a means of clearly representing complex information was a style initiated by the Yorkshire & Humber region.

This imagery has been used extensively across national programme since then.

2006

Sankey Diagrams

Sankey Diagrams are a means of prioritising activity by displaying potential impact of changes to a process.

NISP Yorkshire & Humber used Sankey diagrams to represent Environment Agency data for strategic analysis.

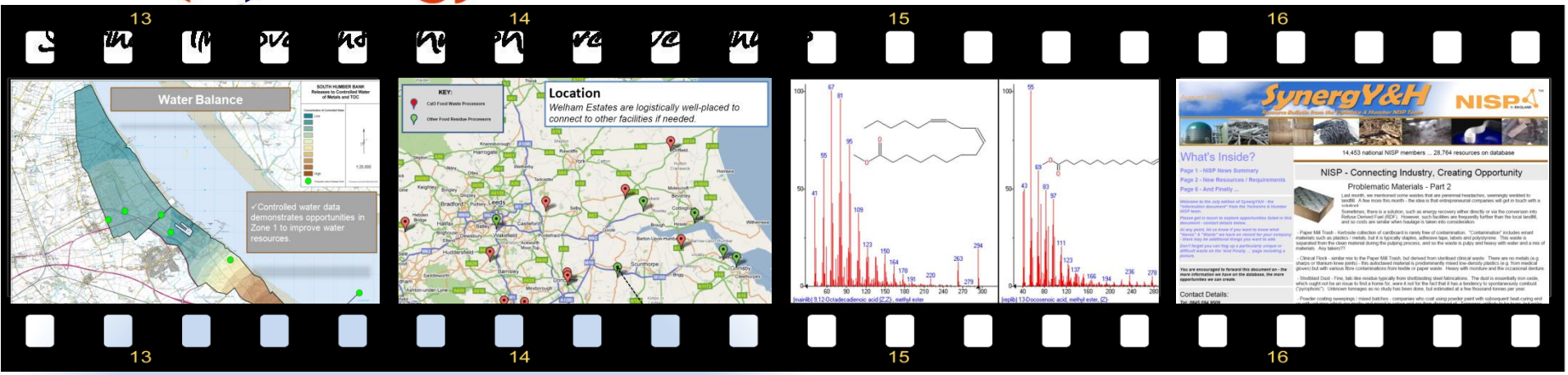
2007

Cluster Mapping

Representing synergies in active cluster diagrams shows emerging patterns an and identifies productive solution-providers.

These diagrams also give visual record of the activity undertaken with core materials to stakeholders.

Innovation Timeline



2008

GIS Mapping

NISP Yorkshire & Humber undertook project to map the utility resource availability on the South Humber Bank.

This opened the possibility of industrial symbiosis on the Bank on a major scale which would lead to significant investment and job creation.

2009

Proximity Mapping

Since 2009, NISP Yorkshire & Humber have explored company-specific opportunities on a ‘proximity basis’, mapping the companies within an agreed radius of the target site.

This approach has improved our service provision to regional members.

2010

University Projects

A number of MSc projects were instigated in 2009/10, exploring innovative opportunities for problematic waste streams as diverse as fatty acids, heavy metal sludges and fish skins.

These projects have successfully brought together industry and academia across the region.

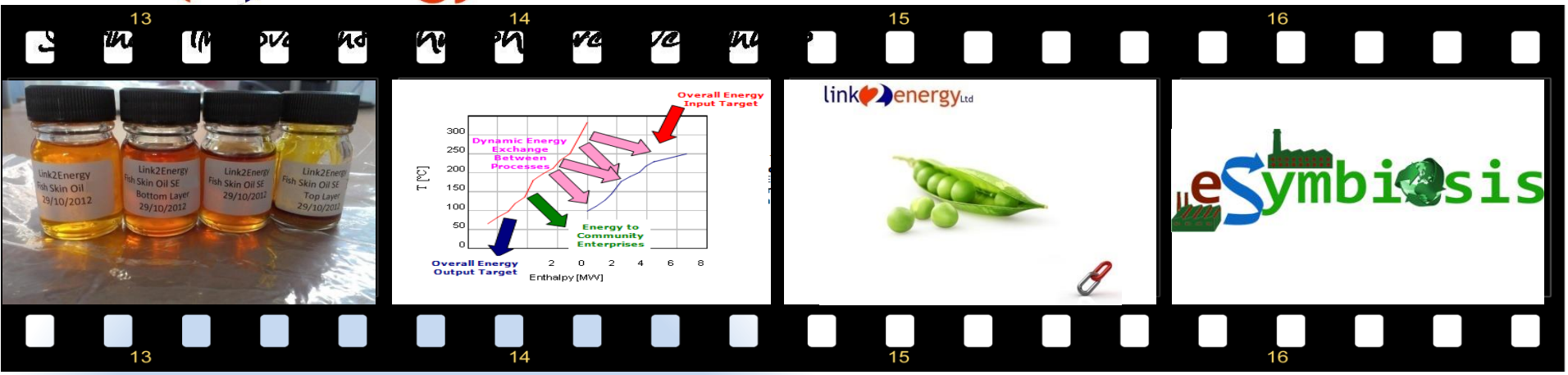
2011

Resource Bulletin

Fresh resources are sent out to 700 regional members in a monthly operational bulletin, initiating dialogue with companies and widening the scope of opportunities.

This practical approach is proving instrumental in maintaining the profile of the regional NISP programme as well as driving delivery.

Innovation Timeline



2012

TSB Awards

Link2Energy Ltd awarded TSB project to research biochemical extracts of marine byproducts in particular fish species.

FP7 LOCIMAP Project

EU Framework Programme project to support the development of **LO**w **C**arbon **I**ndustrial **MA**nufacturing clusters, modelling technical opportunities for high-energy industries

Spark Award

Academic collaboration to research the potential for extracting high-value chemical constituents of pea pods.

EU Life Programme

Development and specification of eSymbiosis product, leading towards second-generation Industrial Symbiosis methodology

Moving from Resource Efficiency to Resource Innovation

Innovation Timeline

2013 : Part 1

Re:Sourcing UK

Launch of Re:Sourcing UK, a service designed to enhance recycling by engaging as an information interface between manufacturers and specialist recyclers

N8 Partnership

Link2Energy actively involved in innovation workshop in conjunction with the N8 Research Partnership – "*Transforming Biowaste To Feed Polymer Supply Chains*"

Resource Portal

The Re:Sourcing UK web portal developed and launched, allowing for engagement with companies on a national level, to understand their waste resources and provide support through our unique Re:Sourcing UK model.

SBRI Critical Materials

TSB-funded investigation into the feasibility of recovery of EU Critical Materials from large-scale industrial waste sources such as ashes or filtercakes.

Moving from <u>Resource Efficiency</u> to <u>Resource Innovation</u>

Innovation Timeline

2013 : Part 2

Bespoke Research

Link2Energy Ltd commissioned to undertake targeted resource-related research on behalf of organisations seeking specific feedstock.

Poultry Litter

Carbogen Ltd secures two project allocations to research possible technologies for reducing environmental impact of poultry litter in Northern Ireland.

Perishable Foods

Link2Energy Ltd part of wider consortium of companies exploring the potential for recovering perishable 'by-products' from the agricultural or food production supply chain for use in new ingredients

NERC Projects

Link2Energy participating in NERC projects, contributing insight and information to a number of preliminary workshops, such as the recovery of WEEE and the extraction of valuable metals from leachate.

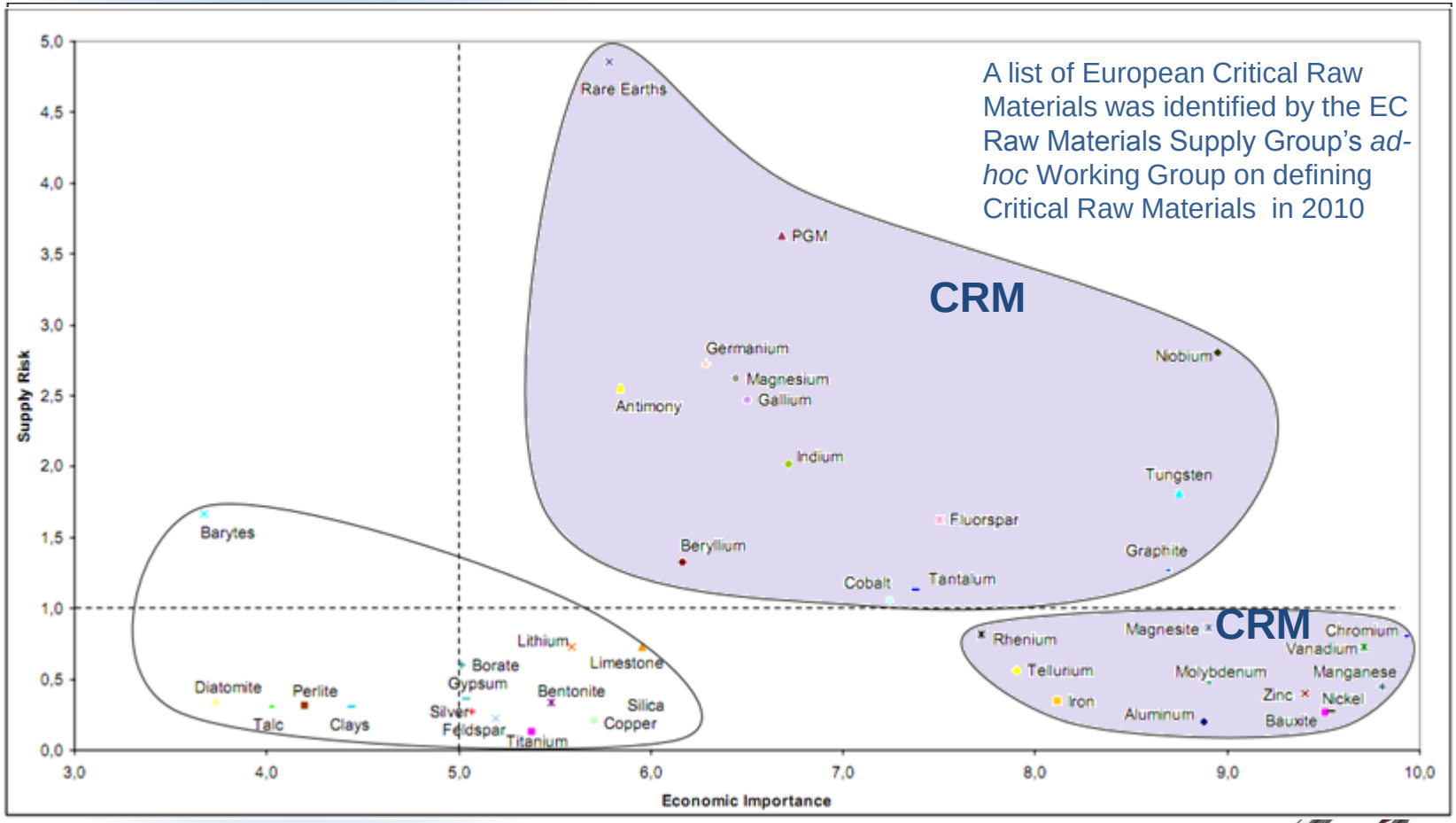
Moving from Resource Efficiency to Resource Innovation

What will 2nd and 3rd Generation of Industrial Symbiosis Look Like?

1. Not just Tonnage....but Value

The Need: Identified CRMs in the EU

Economic Importance and Supply Risk of 41 Materials (EU)



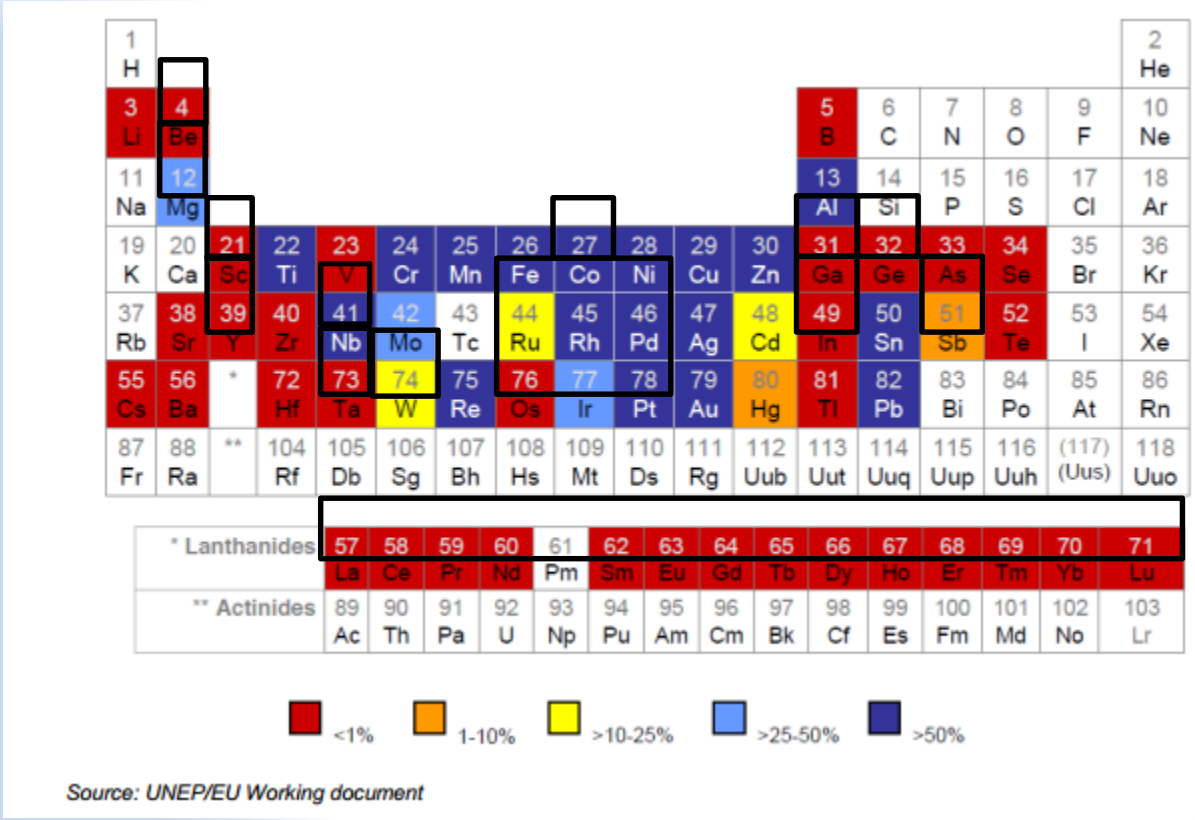
Source: EC Raw Materials Supply Group's *ad-hoc* Working Group on defining Critical Raw Materials 2010

The Need: Current Recovery of CRMs

Metal Recycling Rates (2011)

Many CRMs (outlined in black) have recovery rates of less than 1% (shown in red)

EC CRM



Under 1% recovery = Beryllium, **REEs**, Tantalum, **Osmium**, Gallium, **Germanium**, Indium
(**Bold** are in top 4 EC supply risk)

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SBRI Funded Project:

“Closing The Loop On Industrial Residues”

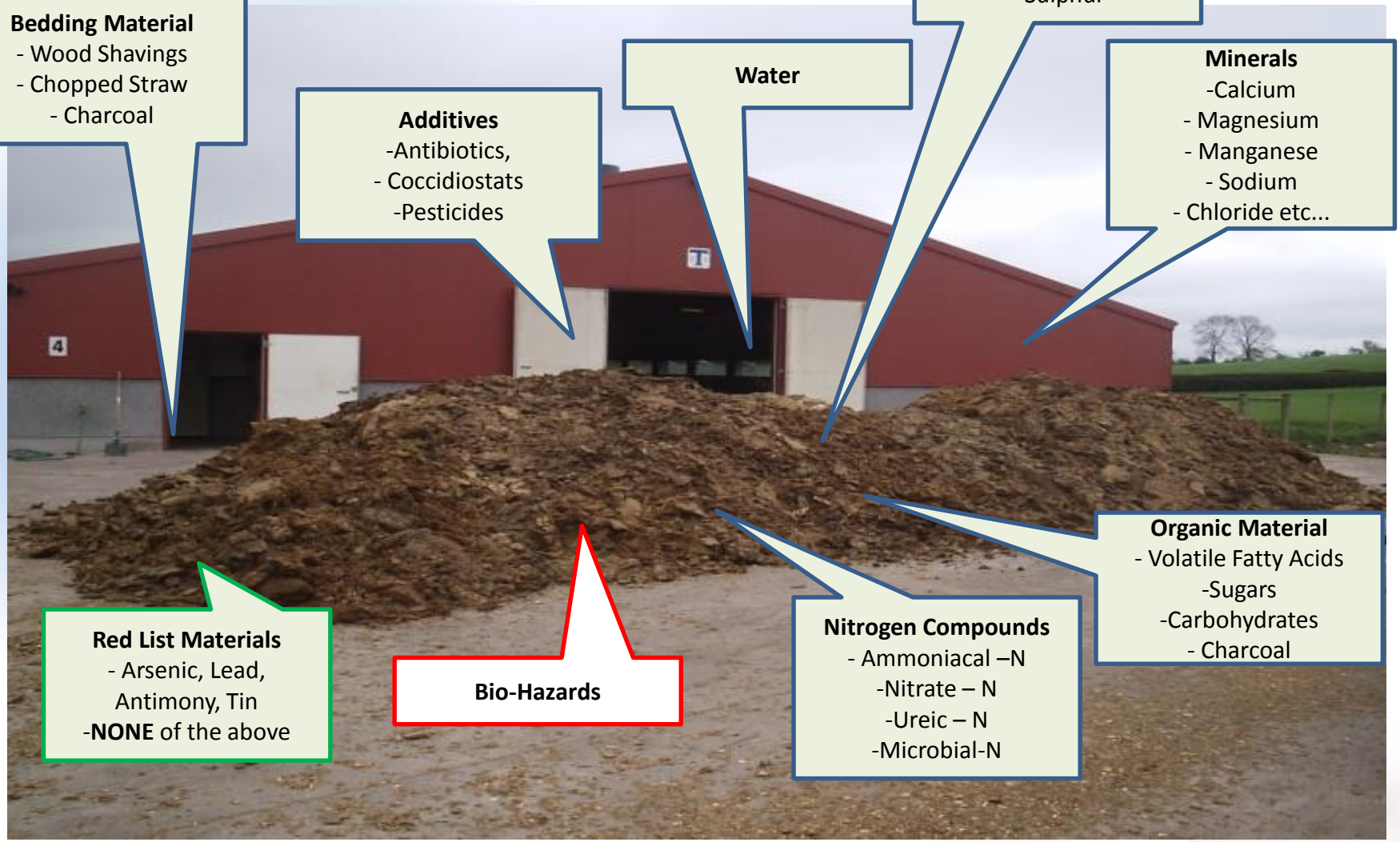
Non-exhaustive mapping exercises in and around the Yorkshire & Humber region alone identified the continuous discharge of industrial residues, potentially rich in those critical raw materials, amounting to a minimum of **6-7 million tpa** with a further **20-30 million tonnes** available as industrial waste bi-products that have been landfilled from historic operations.

Filter Cake, Ash, Sludges, Foundry Dusts, Effluent Cake, Arc Furnace Dust, Phosphgypsum, Titanogypsum, EP Dusts etc.

Screening exercises of those residues using XRF analysis have further confirmed the presence of many critical raw materials including **Cobalt, Antimony, Niobium, Yttrium, Scandium, Neodymium, Cerium, Praseodymium** and **Samarium**.

Estimated inherent value = $17 billion

SBRI Government challenges. Ideas from business. Innovative solutions.


Bedding Material
- Wood Shavings
- Chopped Straw
- Charcoal
Additives
-Antibiotics,
- Coccidiostats
-Pesticides
Water
Nutrients
-Phosphorus
- Potassium
- Sulphur
Minerals
-Calcium
- Magnesium
- Manganese
- Sodium
- Chloride etc...
Organic Material
- Volatile Fatty Acids
-Sugars
-Carbohydrates
- Charcoal
Nitrogen Compounds
- Ammoniacal –N
-Nitrate – N
-Ureic – N
-Microbial-N
Bio-Hazards
Red List Materials
- Arsenic, Lead, Antimony, Tin
-NONE of the above

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10.0 The Case for Hydrothermal Carbonisation with Nutrient Recovery

1. The primary issue of the treatment of the bio-hazardous nature of poultry litter through sterilisation has been addressed; an NPK fertiliser has been produced in a form that enables phosphate to be removed from the Northern Ireland agri-system

2. The process concept is that of advancing the sustainable use of poultry litter by extracting value from all components in the manner of a bio-refinery.

3. Hydrothermal carbonisation (HTC) technology has been demonstrated in an innovative two-stage HTC process.

4. A range of low NO_x bio-coals with calorific values between 20GJ/te and 29GJ/te have been produced. These are potentially suitable for industrial fuel and power sector markets, as a peat replacement and as bio-fuel for the heating systems in the new style poultry sheds.

5. Deployment of this process technology at an industrial cement works is seen as providing an exemplar case study in industrial symbiosis with provision of renewable fuel and bonus opportunities for trading carbon credits in the EU ETS

6. Produced a solid NPK fertiliser for export.

7. Developed the opportunity for the production of bio Hydrogen

8. Presents a 'short' process which addresses the issues set out in the competition

...and ,....

9. Defined two separate '*Bolt-In*' options to create 'longer' processes. Each bolt- in serves two purposes; they increase energy export and enhance product quality.

10. Delivered on a sustainable process zero solid, liquid (except water) and Gaseous emissions and makes the case for it to fall outside the Waste Incineration Directive

What will 2nd and 3rd Generation of Industrial Symbiosis Look Like?

1. Not just Tonnage....but Value
2. Not just Some...but All....Closing the Loop

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Business Improvements Through Creative Thinking

LOCIMAP Future Industrial Parks

Project Coordination

- **North East Process Industry Cluster** (NEPIC) as Project Coordinator

Four Industrial Parks

- **Wilton/Semcorp Utilities (UK) Ltd** – a multinational owner and operator of industrial parks including the UK's largest petrochemical park
- **Kalundborg Kommune** - a leading example of industrial symbiosis in action
- **Tarragona/BASF Espanola SL** - operators of a large petrochemical complex
- **Kokkola Industrial Park** - a major industrial park in Finland specialising in inorganic chemistry

Five Industrial Partners/Sector Specialists

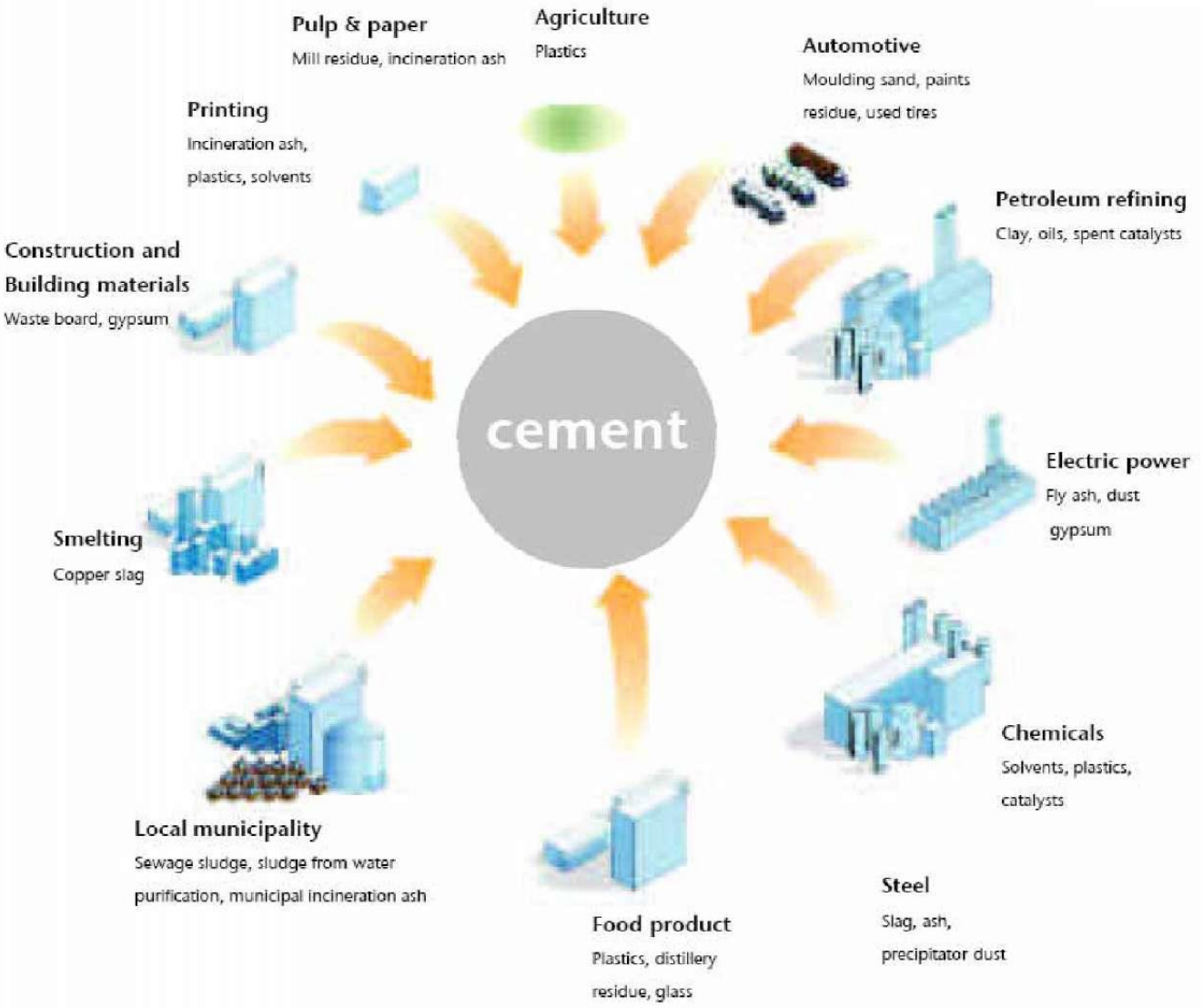
- **Cemex UK Limited** - a leading cement manufacturer
- **Papiertechnische Stiftung (PTS)** - the leading research body in Paper and Pulp manufacture based in Germany
- **Terreal SAS** one of Europe's most innovative clay products manufacturers
- **VDEh-Betriebsforschungsinstitut GmbH (BFI)** - development of Iron & Steel manufacturing technology in Germany
- (**Phillips66** - Oil Refining on the Humber and operators of Europe's largest CHP unit)

Four Technical Specialists

- **Parsons Brinckerhoff Sp - engineering and energy consultants**
- **Institut Européen D'Administration Des Affaires** (INSEAD) - one of Europe's leading business schools
- **IVL Svenska Miljoeinstitutet AB** - a prominent environmental research institute
- **Link2Energy Ltd** - a specialist company focused on resource innovation and industrial symbiosis

Promotion

- **European Chemical Site Promotion Platform** (ECSPP) - promoting the interests of European Chemical Sites



Source: WBCSD *Getting the Numbers Right,* 2011

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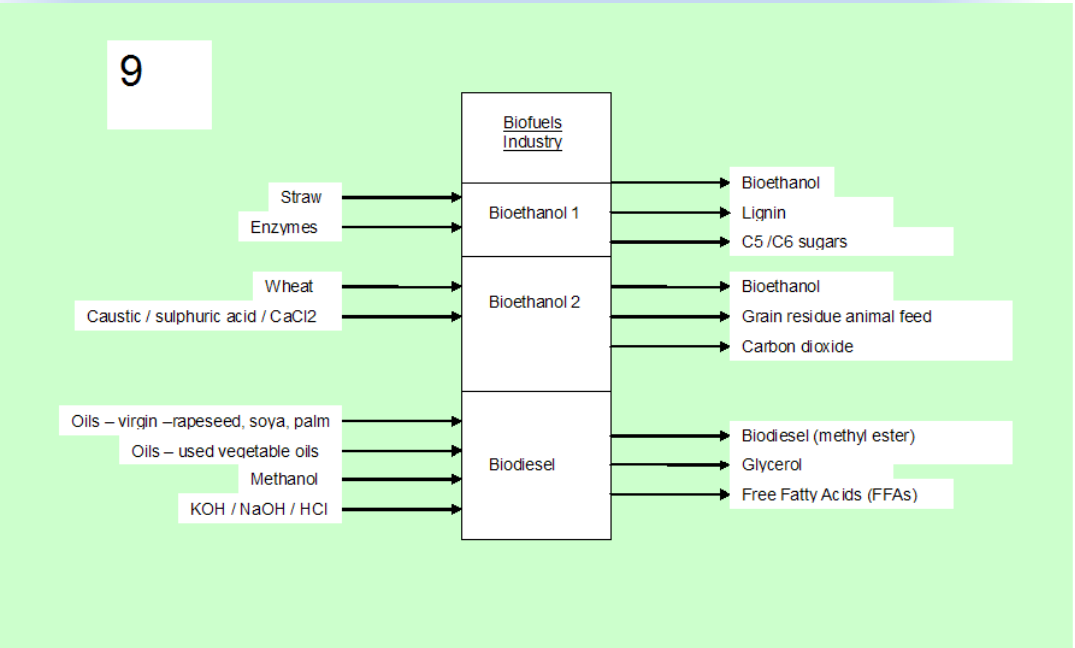
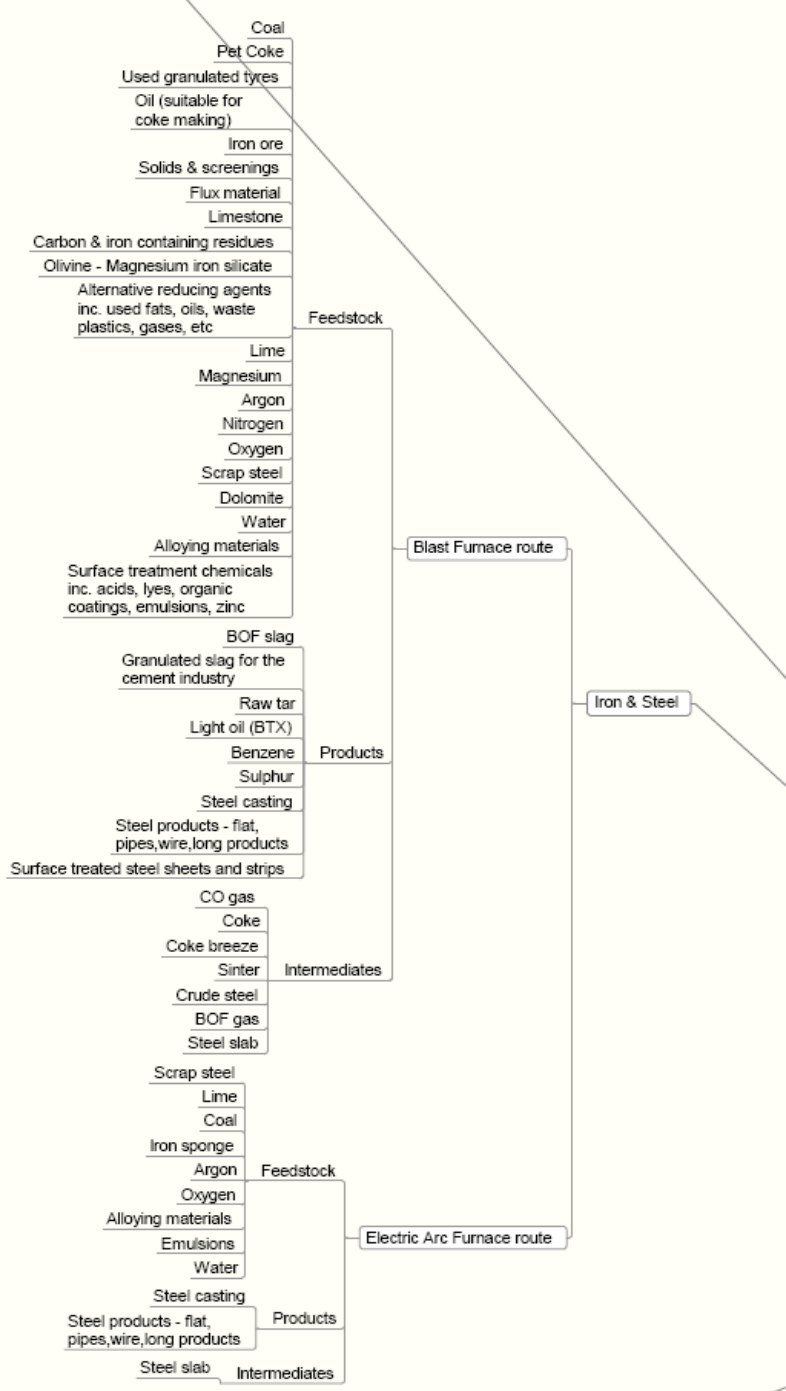
Assessment of Materials Integration Potential

The input-output diagrams from the Iron & Steel industry translated onto a mindmap





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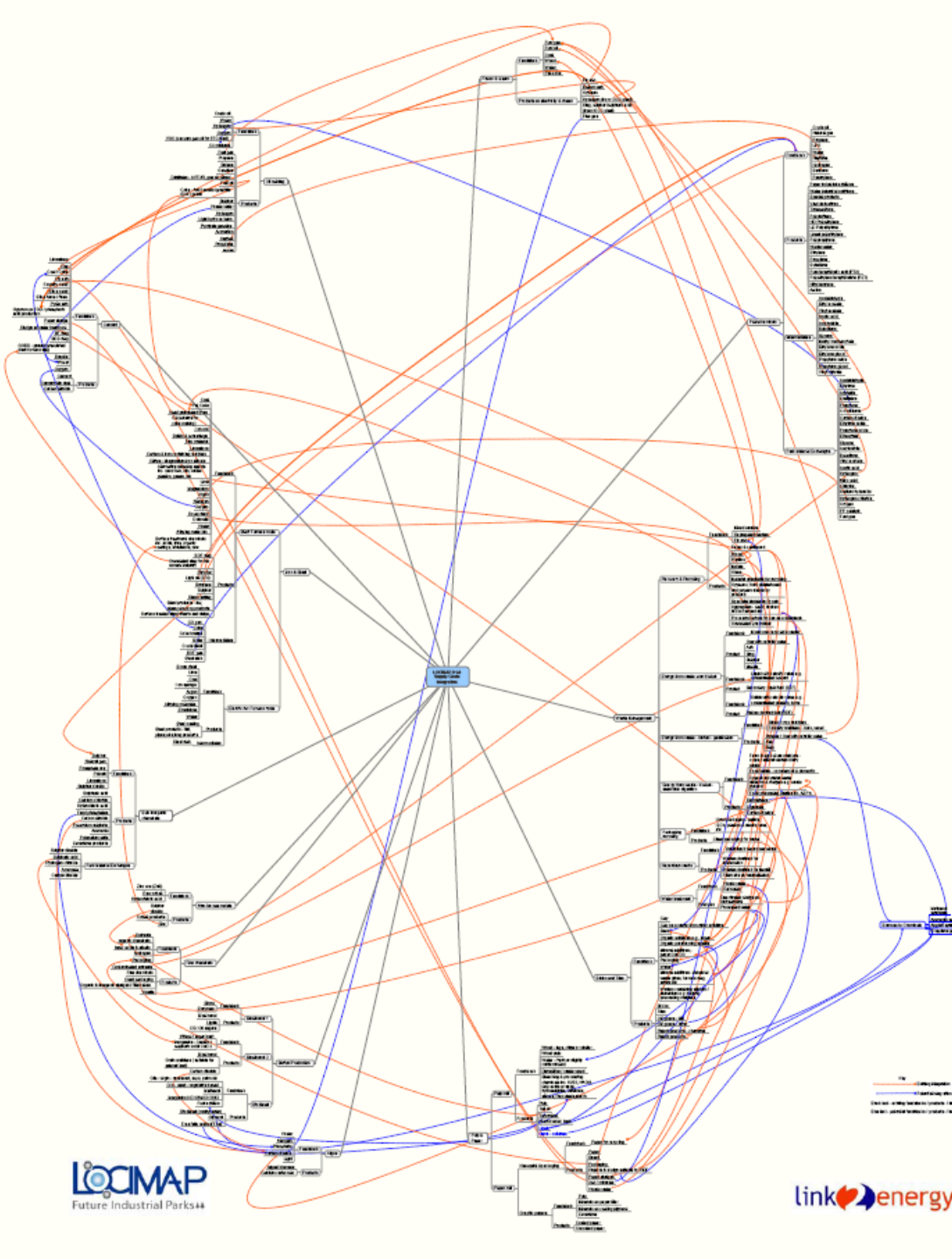
Assessment of Materials Integration Potential

The Full Potential...**and Defining the Challenge of a Closed Loop Economy**



LOCIMAP

Future Industrial Parks

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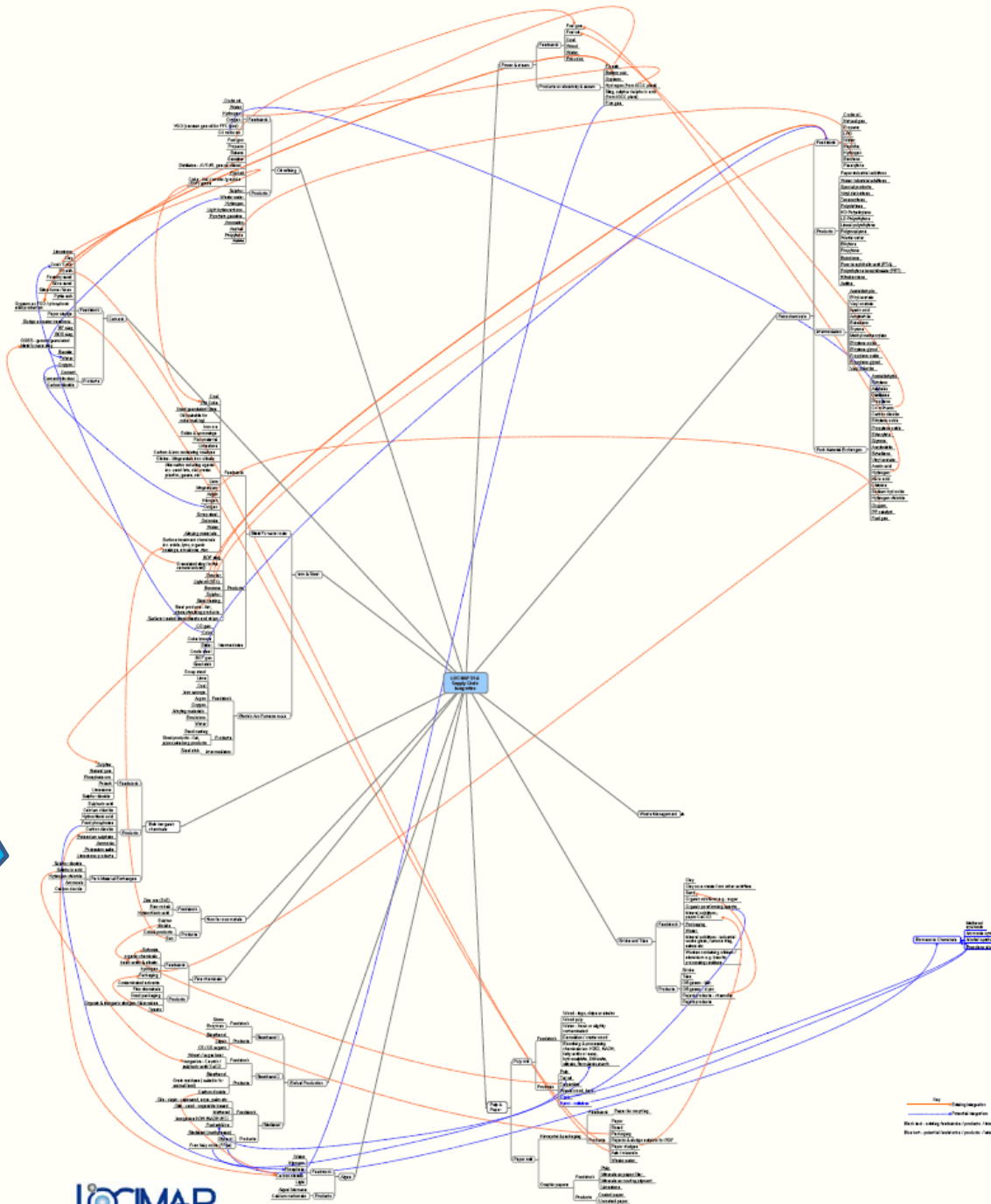
Assessment of Materials Integration Potential

The Importance of the Waste Industry and Post Consumer as well as Post Industrial Integration

- The impact that an Industry has on Closing Materials Loops is Defined



LOCIMAP Future Industrial Parks

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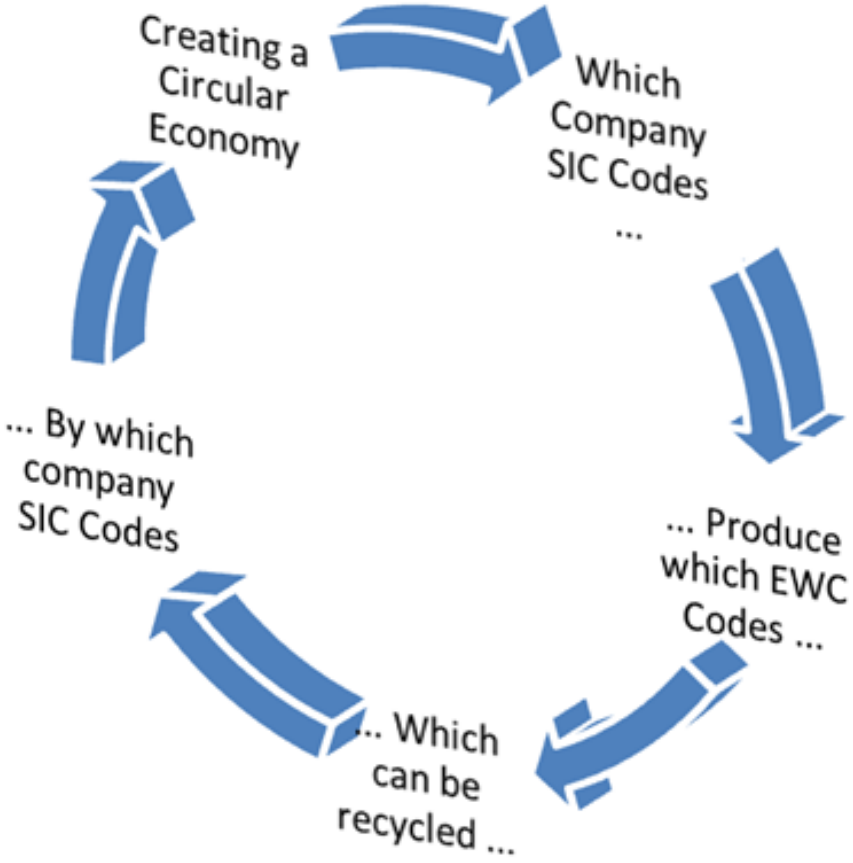
Closing the Loop



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Business Improvement Thinking

SECTOR ROADMAPS

What will 2nd and 3rd Generation of Industrial Symbiosis Look Like?

1. Not just Tonnage....but Value
2. Not just Some...but All....Closing the Loop
3. No just Materials...but Energy

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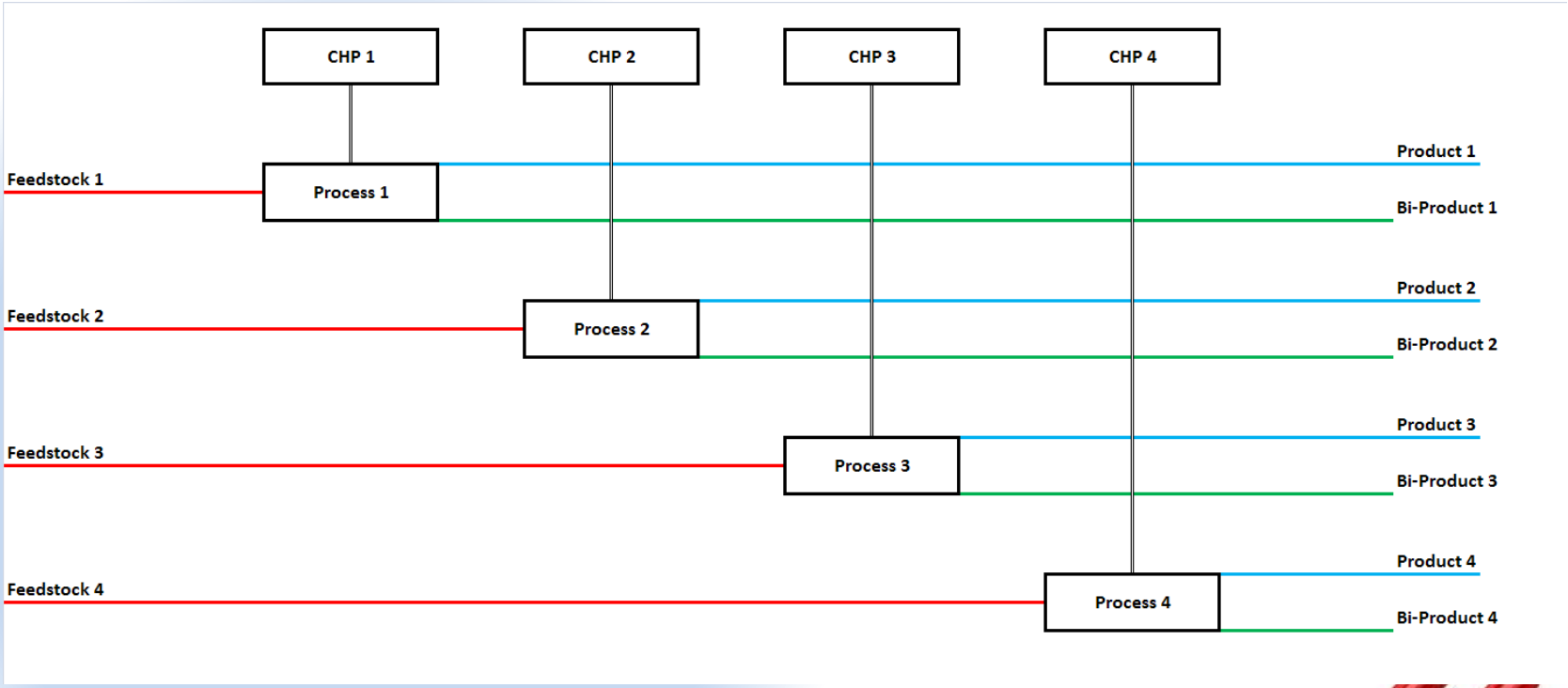
Integration Levels



LOCIMAP

Future Industrial Parks

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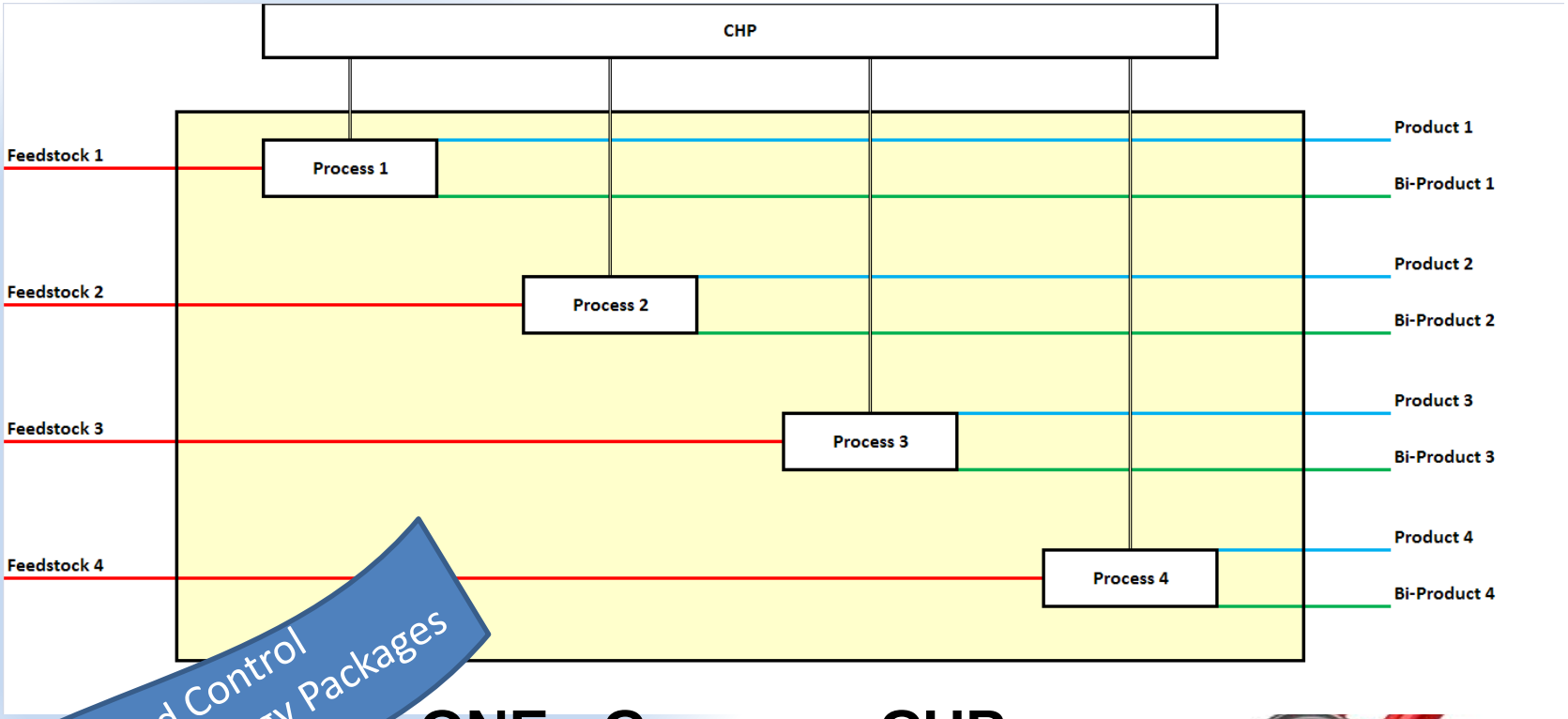
LOCIMAP

Future Industrial Parks



-Advanced Control
-Optimising Technology Packages

ONE : Common CHP

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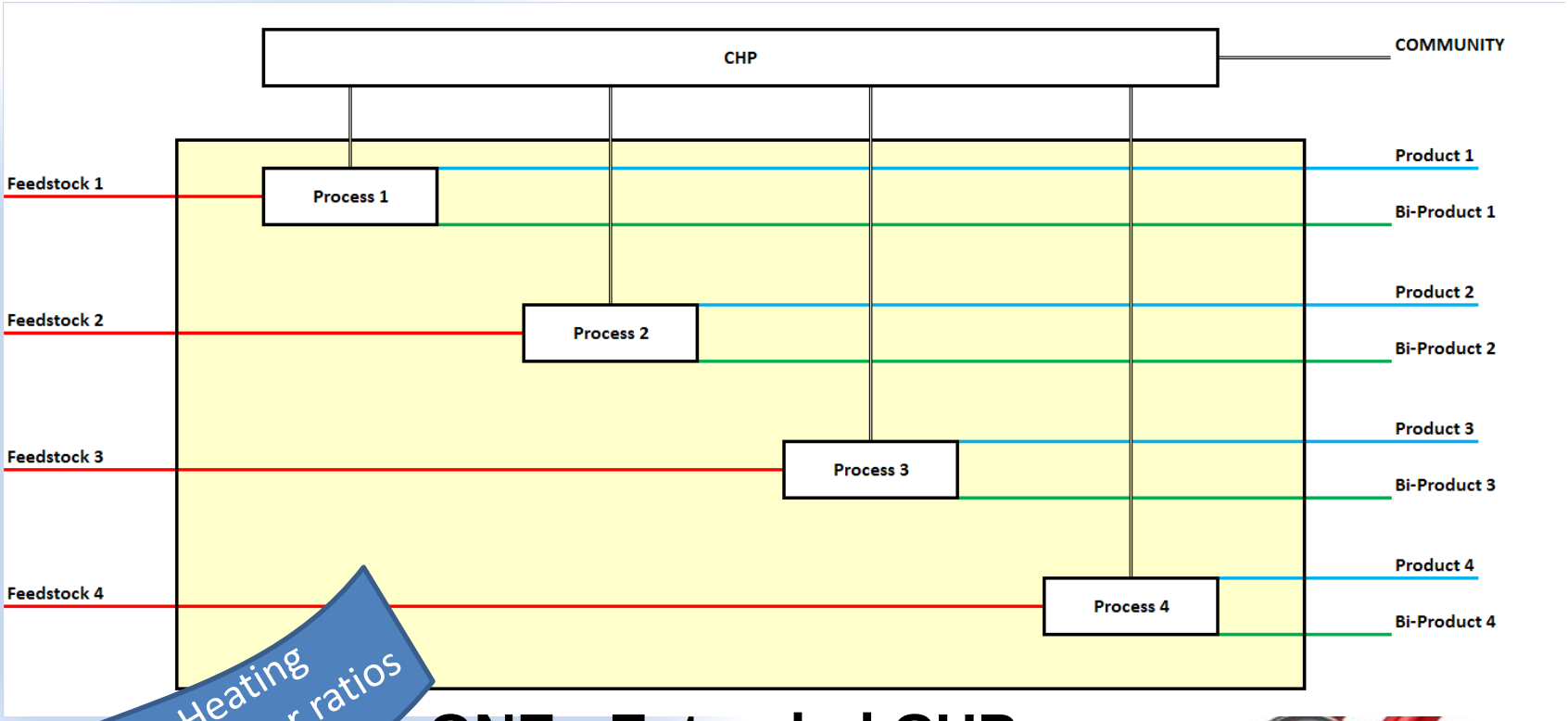
Integration Levels



ONE : Extended CHP

- Community Heating
- Optimised Heat:Power ratios

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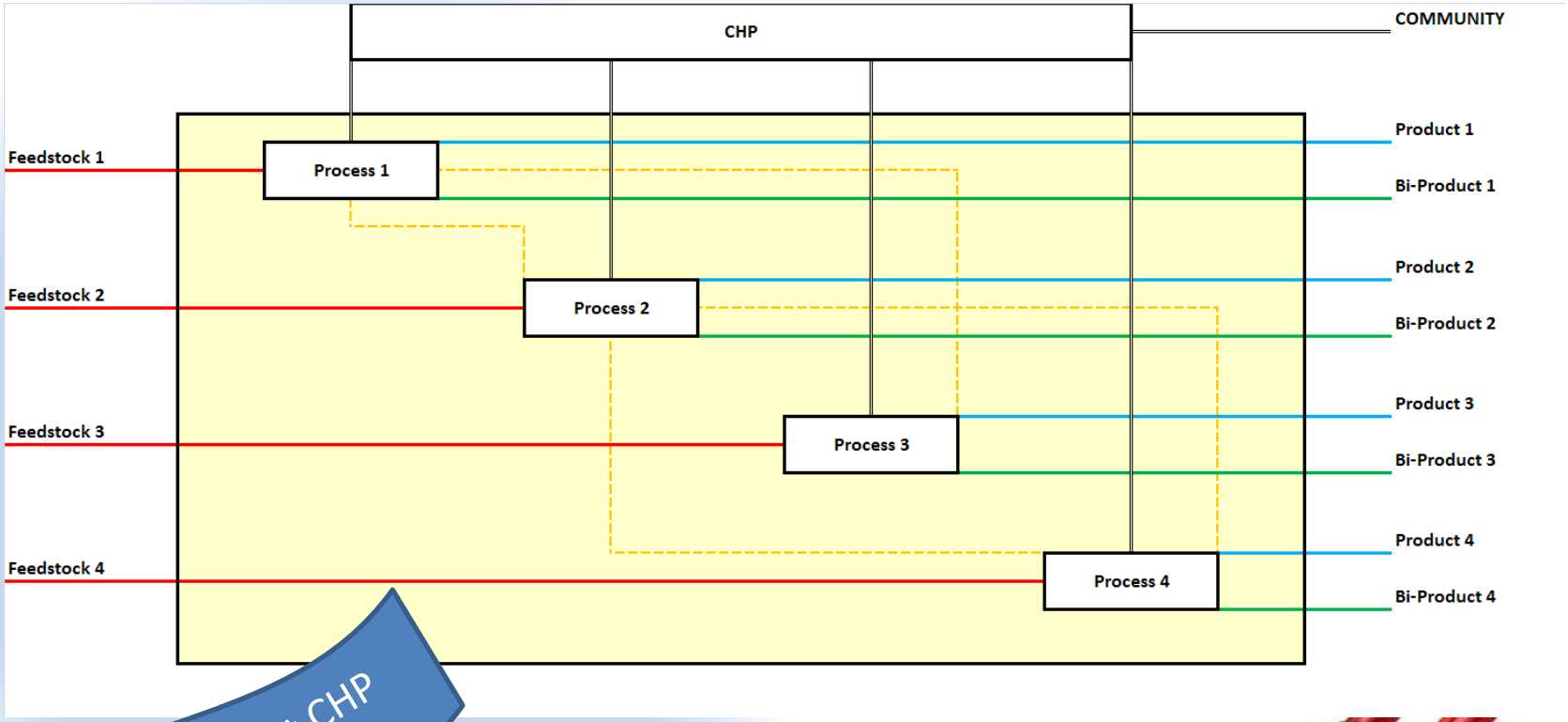
Integration Levels



- Lower footprint CHP

ONE : Extended CHP

TWO: Integrated Processes I

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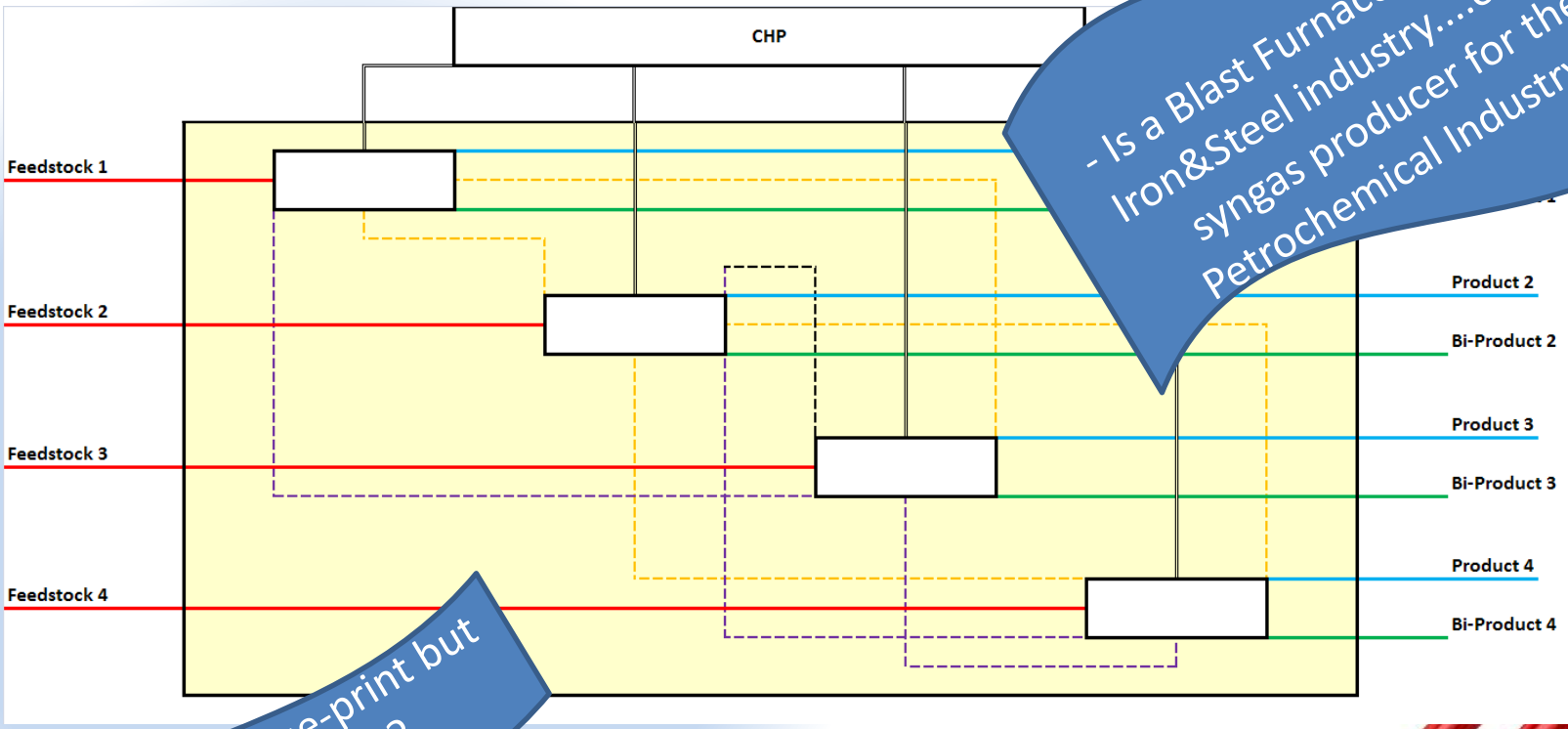
Integration Levels



- Is a Blast Furnace part of the Iron&Steel industry....or is it a syngas producer for the Petrochemical Industry ☺

-Minimum Energy Blue-print but How Far Can We Go?

ONE : Extended CHP

TWO: Integrated Processes I

TWO A: Integrated Processes II

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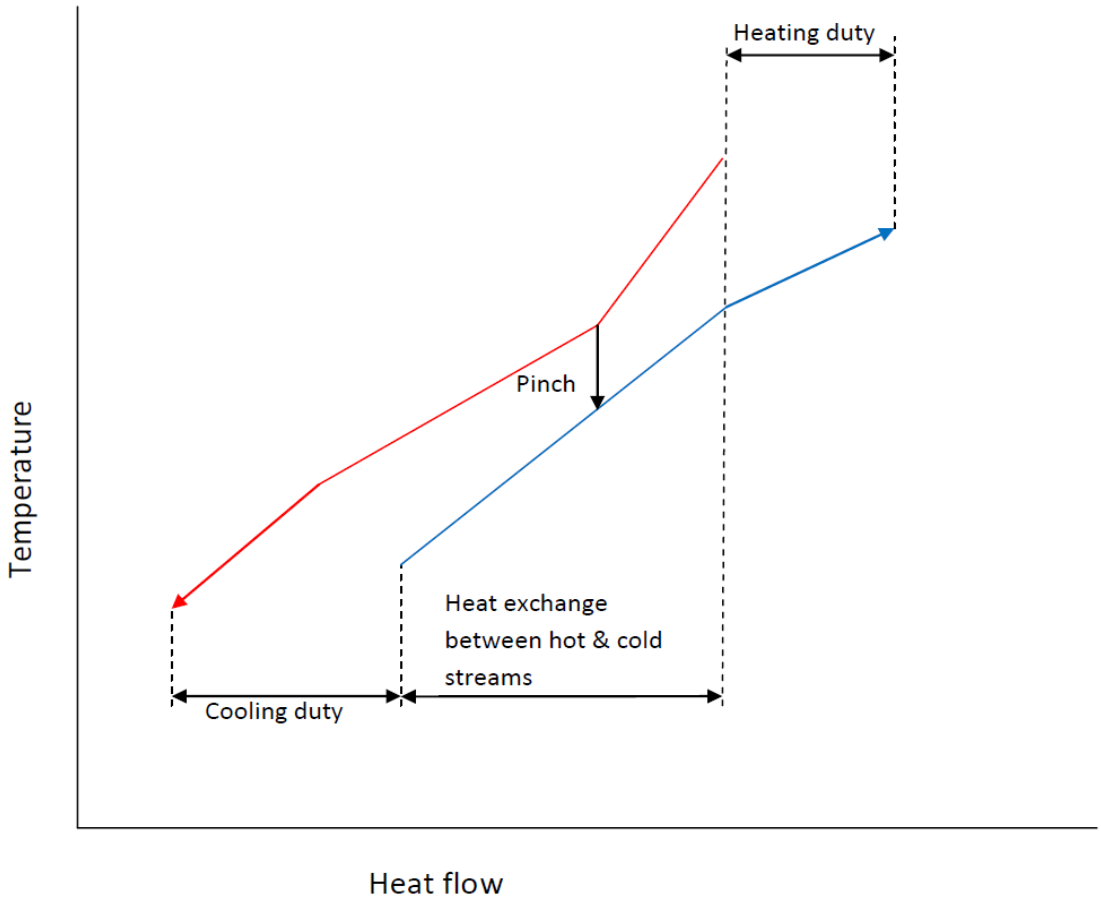
LOCIMAP
Future Industrial Parks

How Do We Define the minimum Energy Requirements....know we are the Best!?

Three Key parameters Derived from Target Setting

1. Minimum Hot Utility Requirement
2. Minimum Cold Utility Requirement
3. Pinch Temperature



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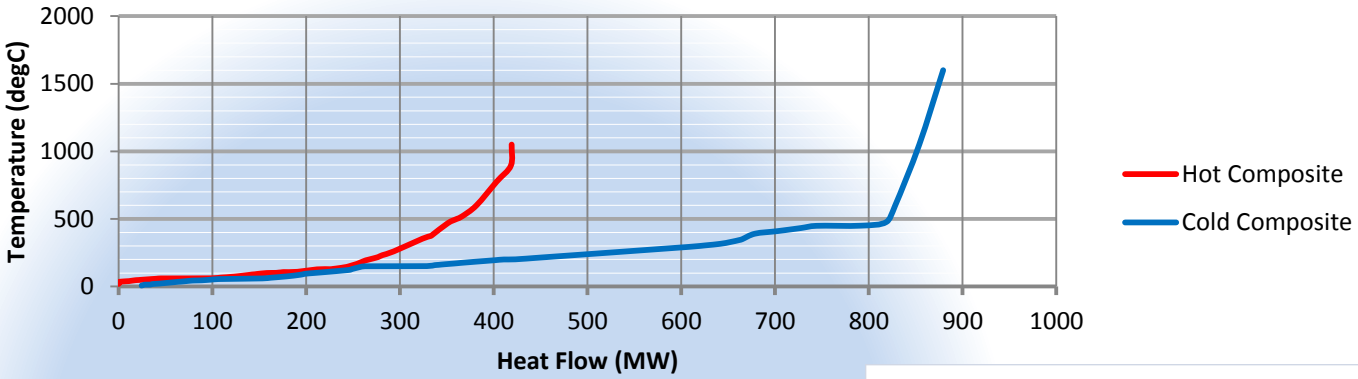
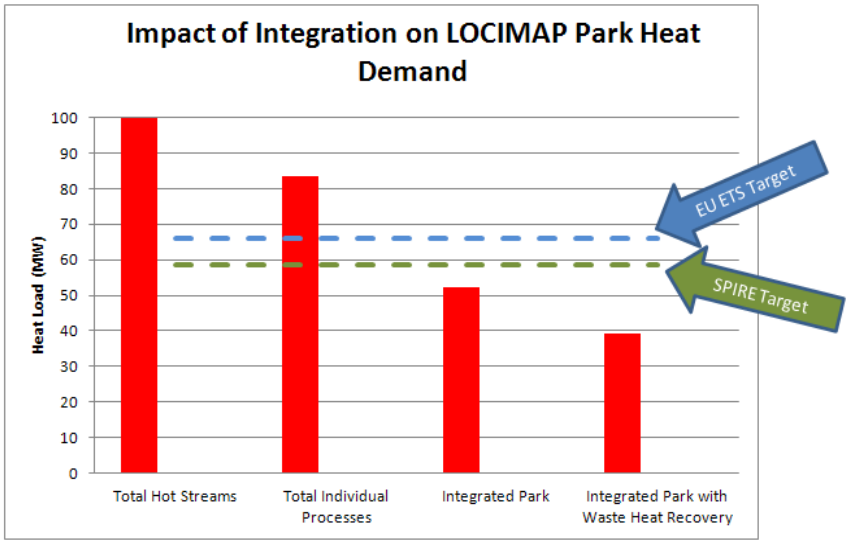
LOCIMAP

Future Industrial Parks



The application of LOCIMAP principles through the appropriate design of industrial parks and the development of opportunities for process integration has the potential to exceed the targets set within EU ETS under which the majority of our participating industries operate i.e. 21% reduction in comparison with 2005, the Europe 20202 figures , and also the targets within SPIRE.



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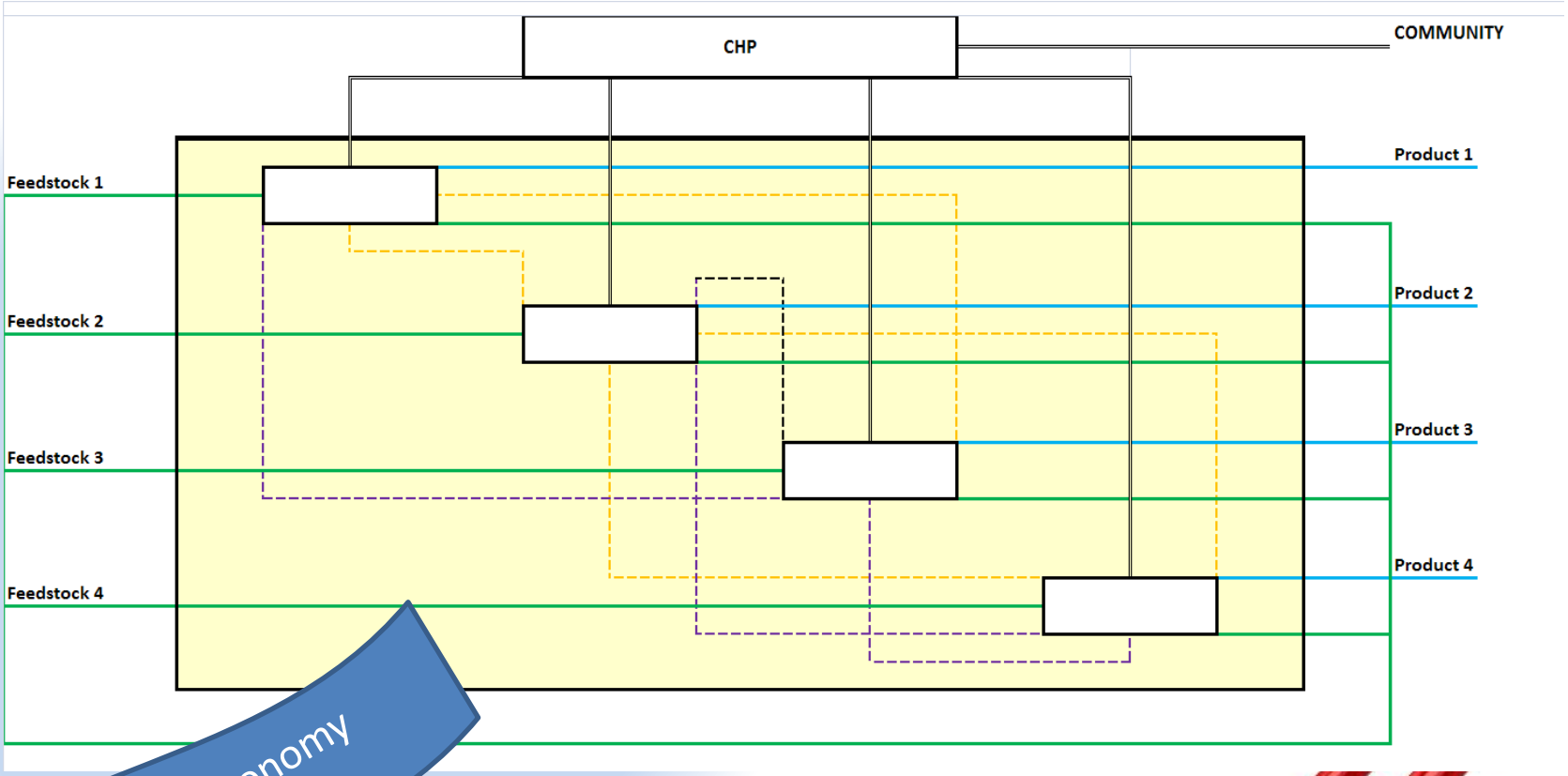
Integration Levels



- Closed Loop Economy

ONE : Extended CHP

TWO: Integrated Processes I

TWO A: Integrated Processes II

THREE: Closing Material Loops

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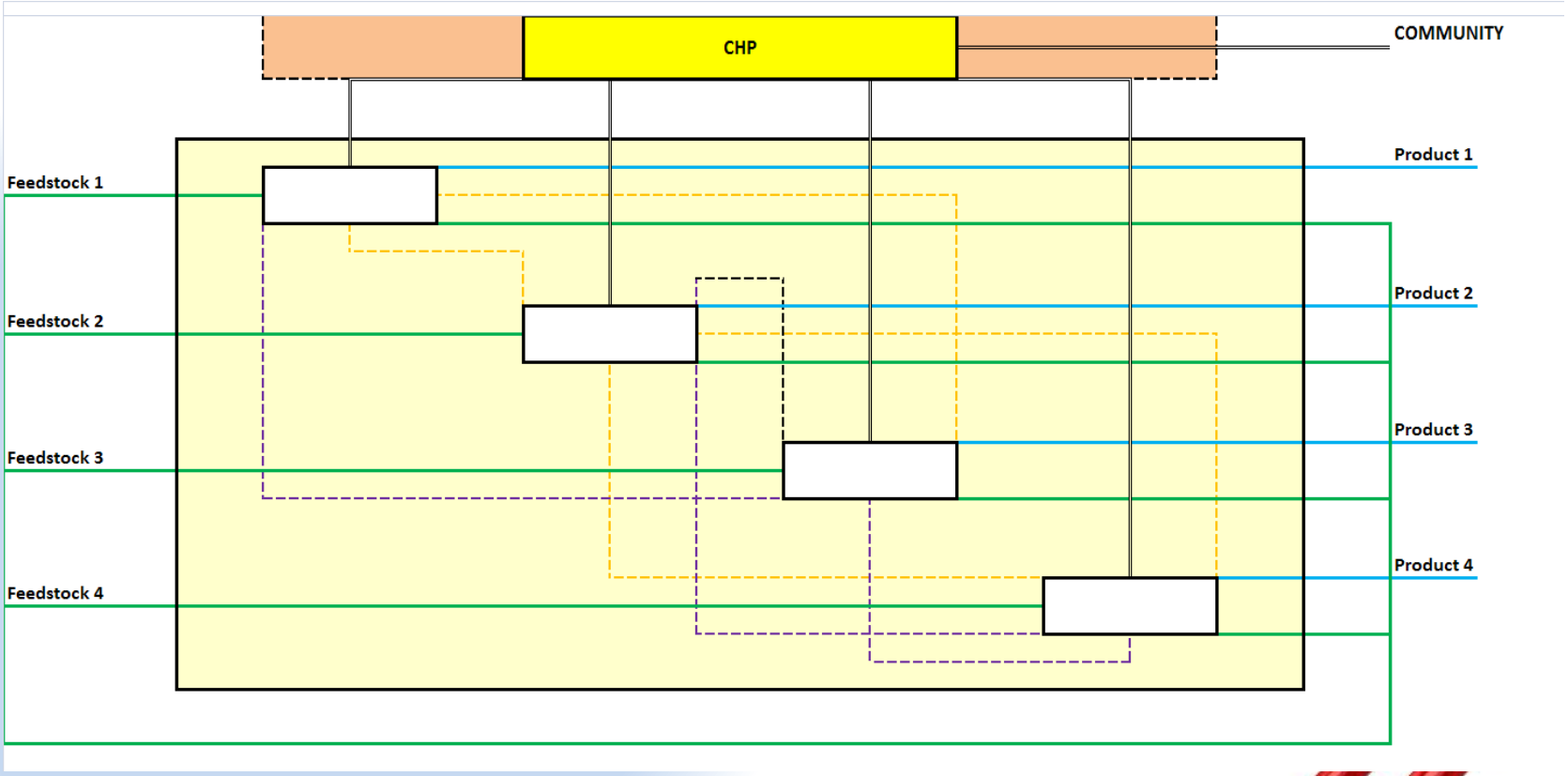
Integration Levels



ONE : Extended CHP

TWO: Integrated Processes I

TWO A: Integrated Processes II

THREE: Closing Material Loops

What will 2nd and 3rd Generation of Industrial Symbiosis Look Like?

1. Not just Tonnage....but Value
2. Not just Some...but All....Closing the Loop
3. No just Materials...but Energy
4. Can We Multi-Task?

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