



# Global trade of recycled plastics: implications for resource recovery and circular economy

Dr Costas Velis



**ISWA**  
*International Solid Waste Association*

Waste Hierarchy – Induced  
Challenges

ISWA European Group meeting  
Brussels 16-17 June 201e



*European Economic and Social Committee*  
**Employer's Group**

# School of Civil Engineering

## Core research institutes



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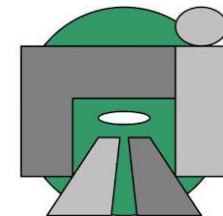


Pathogen Control  
Engineering  
Institute



water@  
leeds

iRI-Institute for  
Resilient  
Infrastructure



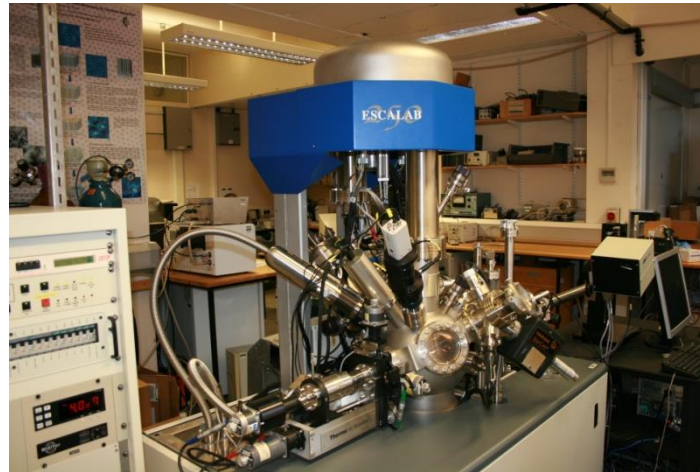
# Energy Resources Institute - Experimental facilities



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- Thermal conversion of biomass
- Small scale laboratory rigs
- Large analytical laboratory
- Water analysis
- Environmental analysis



# Used plastics research at Leeds



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Global post-consumer quantities / composition



Behaviour during thermal processing (thermo-gravimetric methods)



Plastics in marine litter



Flame retardants (PBDEs) safe thermal disposal



Dependencies and optimisation of R1 formula (calorific value influence)



Overall systems value recovery optimisation (C-VORR)

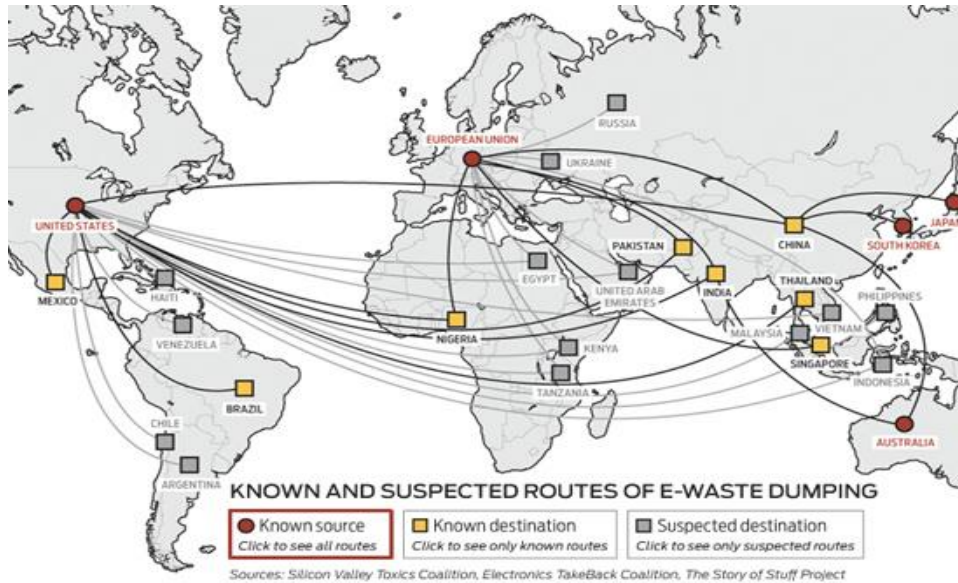


Recycling plastics behaviour in big religious events (Hajj)

# Global scale realities: E-waste distribution



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Source: <http://www.scrapmonster.com/news/barely-4.5-of-indias-e-waste-recycled-assochem/15871>

Source: International electronics recovery coalition, available at <http://www.ierc.info/e-waste-dumping-an-interactive-map/>

# Waste everywhere... Unintended global flows and consequences...



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Plastics ending up at the beach

Source:

<http://thecoolgadgets.com/plastic-eating-marine-microbes-will-it-solve-ocean-plastic-contamination-issue/>



Plastics floating in the ocean

Source:

[http://www.dailygalaxy.com/my\\_weblog/2007/12/are-there-reall.html](http://www.dailygalaxy.com/my_weblog/2007/12/are-there-reall.html)



**Project Coordinator: A. Mavropoulos, ISWA STC Chair**

**Scientific co-ordinator : Prof D. Wilson**

**Members: J. Cooper, B. Appelqvist, C. Velis**

**Examine and make recommendations on issues  
arising from the interaction between globalisation  
and waste management**

**Contributing: more than 60 scientists  
and countless practitioners**

**Web-page:** [http://www.iswa.org/en/685/task\\_force\\_details/tf/show\\_detail/task-force-on-globalisation-and-waste-management.html](http://www.iswa.org/en/685/task_force_details/tf/show_detail/task-force-on-globalisation-and-waste-management.html) Informal

# Globalisation and Waste Management

## ISWA TASK FORCE



### Megacities

Beacon conference -  
Singapore July 2012

ISWA Report on  
Underground SWM  
solutions - in most  
read of Knowledge  
base

'Globalising MFA'  
decision support tool +  
publication

### Informal Sector

International expert  
workshop - Buenos  
Aires 2011

'InteRa' framework and  
tool : WM&R paper and  
CGI keynote  
presentation

ISWA publication  
Award 2013 – in most  
read of WM&R

### Global Recycling Markets

ISWA report:  
Global plastic  
recycling markets

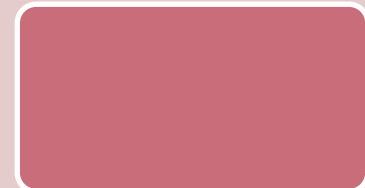
Vienna ISWA  
Congress Special  
Session  
(1) Paper markets and  
(2) Trafficking

Pre-view today  
Generated already  
press interest (2  
Guardian articles)

### International Collaboration and Aid

PhD research partly  
supported by ISWA

'International  
Development aid for  
waste management in  
low and middle income  
countries'

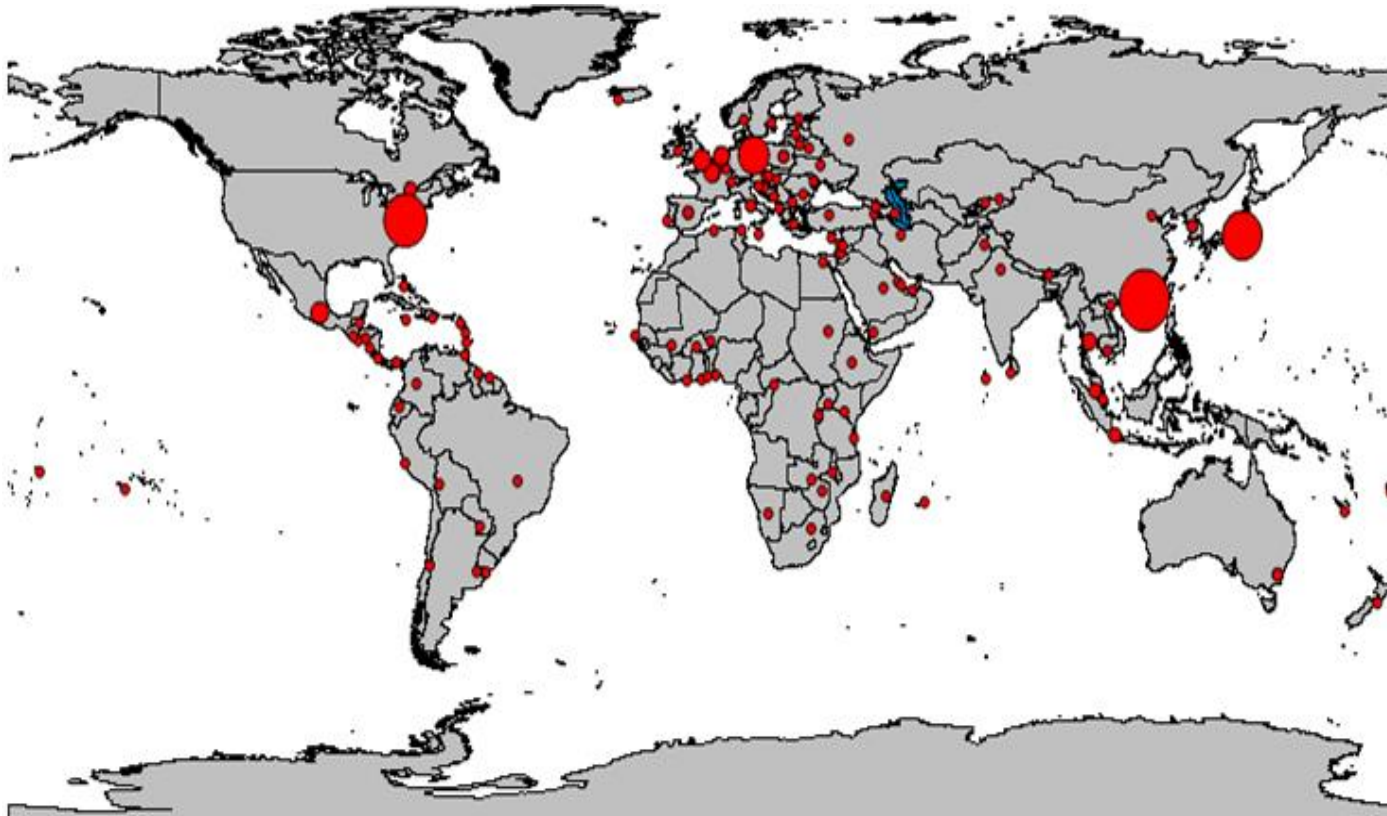




# Global map of export transactions in waste plastic - 2011



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Code 3915:  
“waste, pairings  
and scraps of  
plastics”

Data source:  
(UN Comtrade)

# Top world plastic waste exporters / importers (UN comtrade 2012)



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Top Importers in the selection ([View Map](#))

Reporter Title	Trade Value
<a href="#">China</a>	\$6,109,315,386
<a href="#">China, Hong Kong SAR</a>	\$1,648,137,359
<a href="#">USA</a>	\$217,866,559
<a href="#">Netherlands</a>	\$204,638,745
<a href="#">Belgium</a>	\$179,136,063

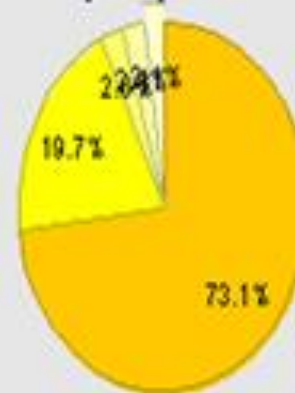
Total Import: \$8,359,094,112

Top Exporters in the selection ([View Map](#))

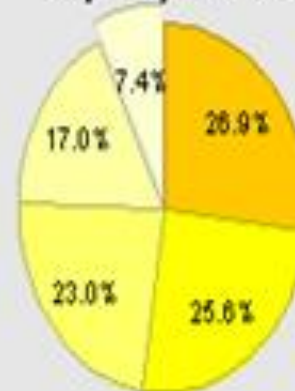
Reporter Title	Trade Value
<a href="#">China, Hong Kong SAR</a>	\$1,105,843,904
<a href="#">USA</a>	\$1,052,355,271
<a href="#">Japan</a>	\$944,978,707
<a href="#">Germany</a>	\$697,069,415
<a href="#">United Kingdom</a>	\$304,747,504

Total Export: \$4,104,994,801

Top Importers



Top Exporters



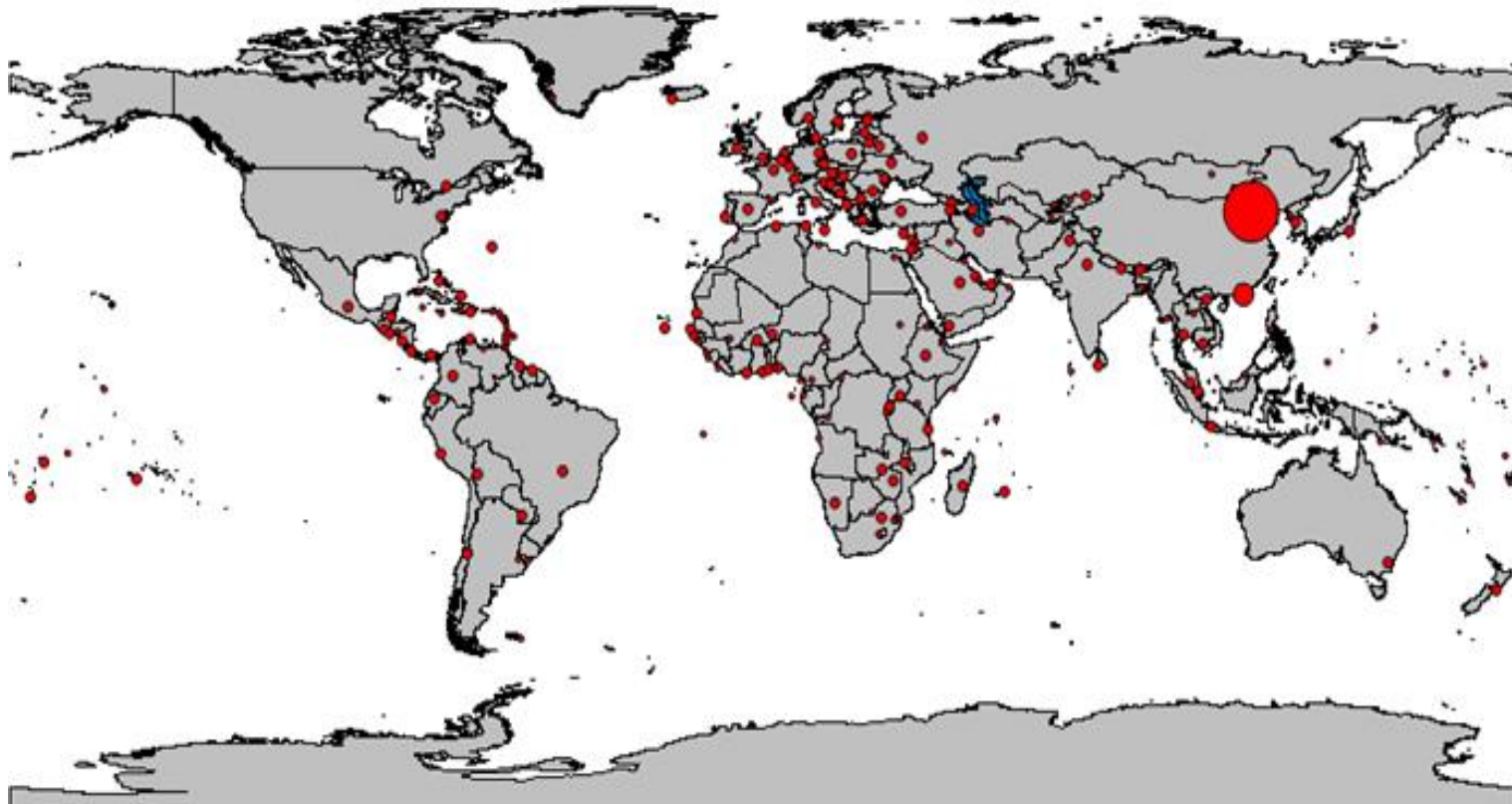
Code 3915:  
“waste, pairings  
and scraps of  
plastics”

Data source: (UN  
Comtrade)

# Global map of import transactions in waste plastic – 2011: China rules!



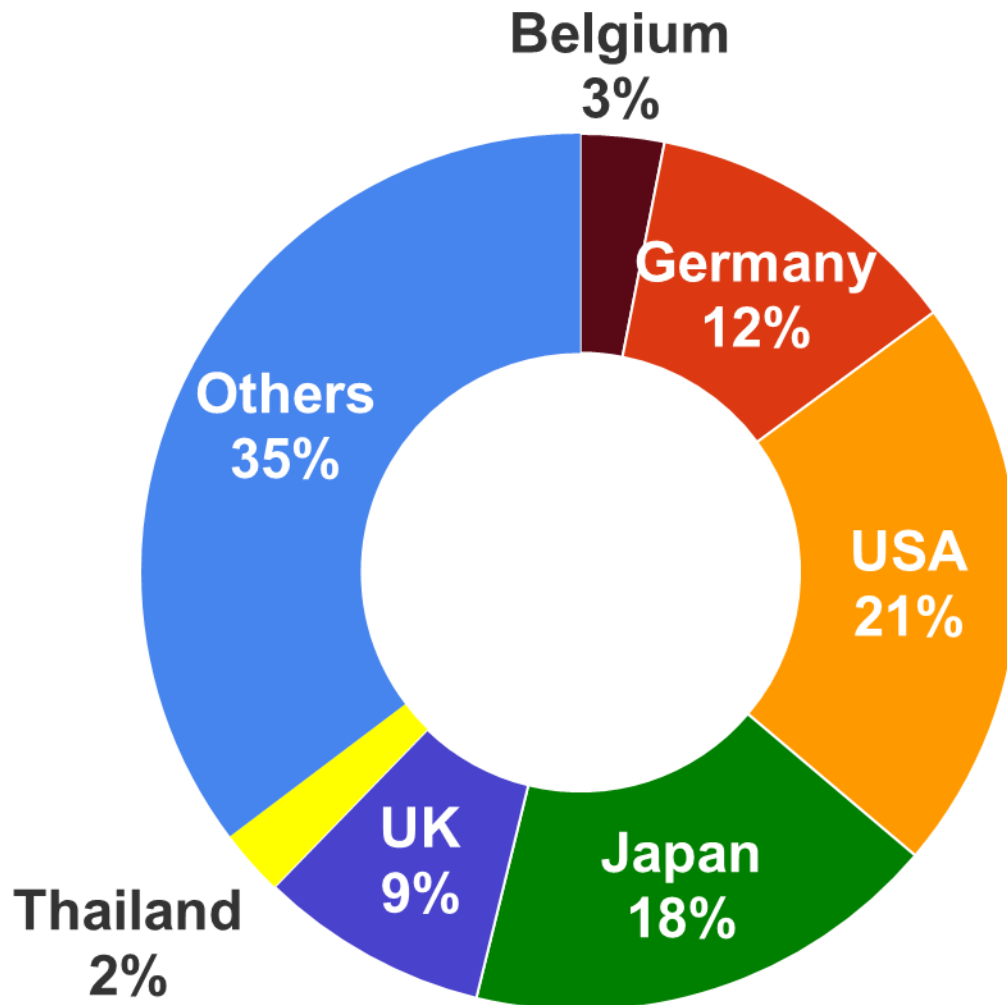
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# World exports of plastics scrap to China including HK SAR in 2011



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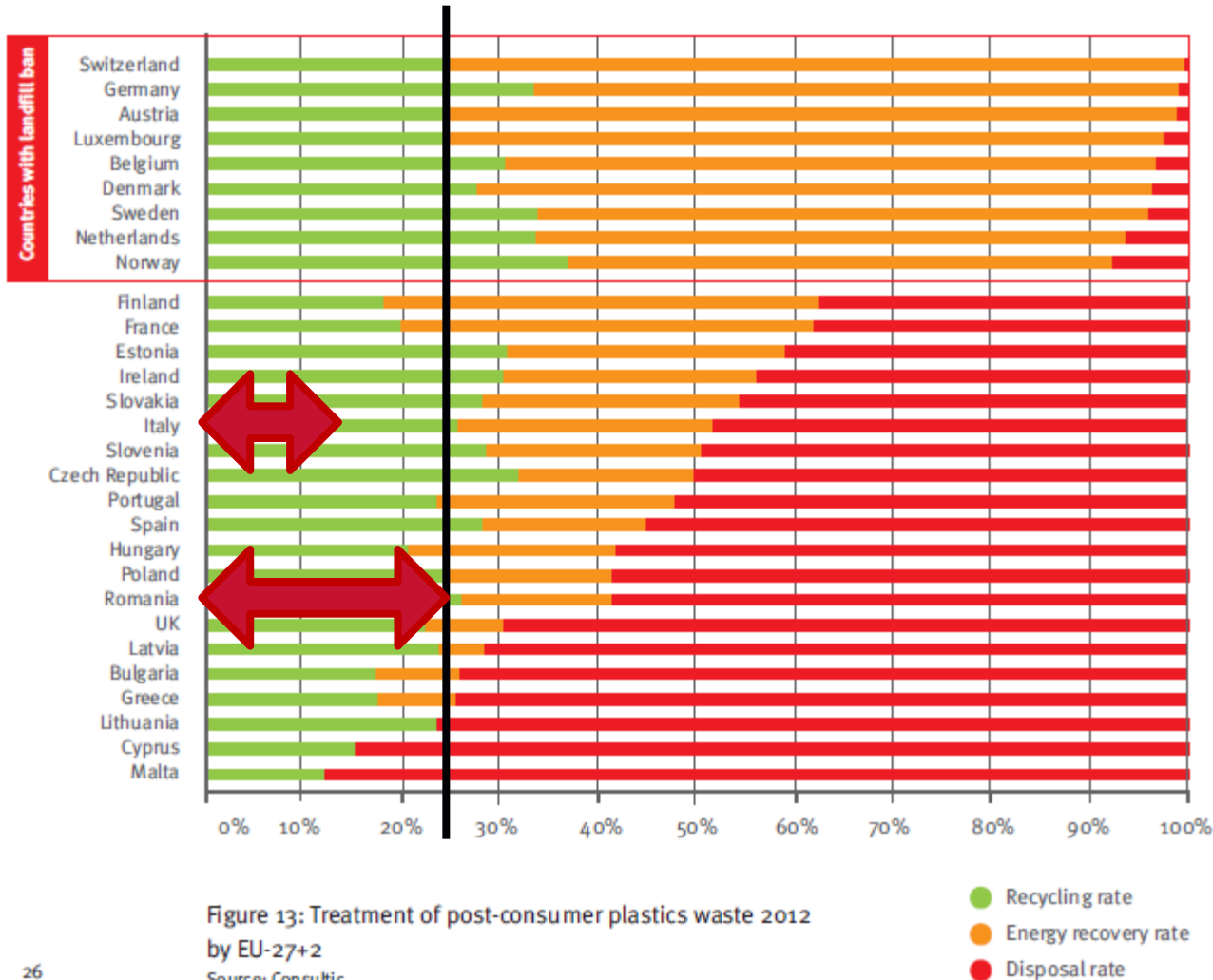


Source: Zhou, 2012

# European waste plastics 'value recovery'



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Adopted from: Consultic,  
as cited by (Plastics  
Europe, 2013)

# Europe depends on exporting to China (87% wt. of exports)



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## ▶ **87% wt. to China + Hong Kong SAR**

- Trend is relatively stable: 2010: 3.373Mt; 2011: 3.365Mt; 2012: 3.358Mt
- Destination (target countries) mainly Asian (South, South East, East)
- Rising trend of direct exports to China, and also to India

## ▶ **Overall dependence on Chinese market demand is even greater!**

- Exports to South-East Asian (ASEAN) countries to a great extent finally find their way towards China

## ▶ **EU-27 imports comparatively insignificant** (0.4 Mt vs.3.4Mt exports)

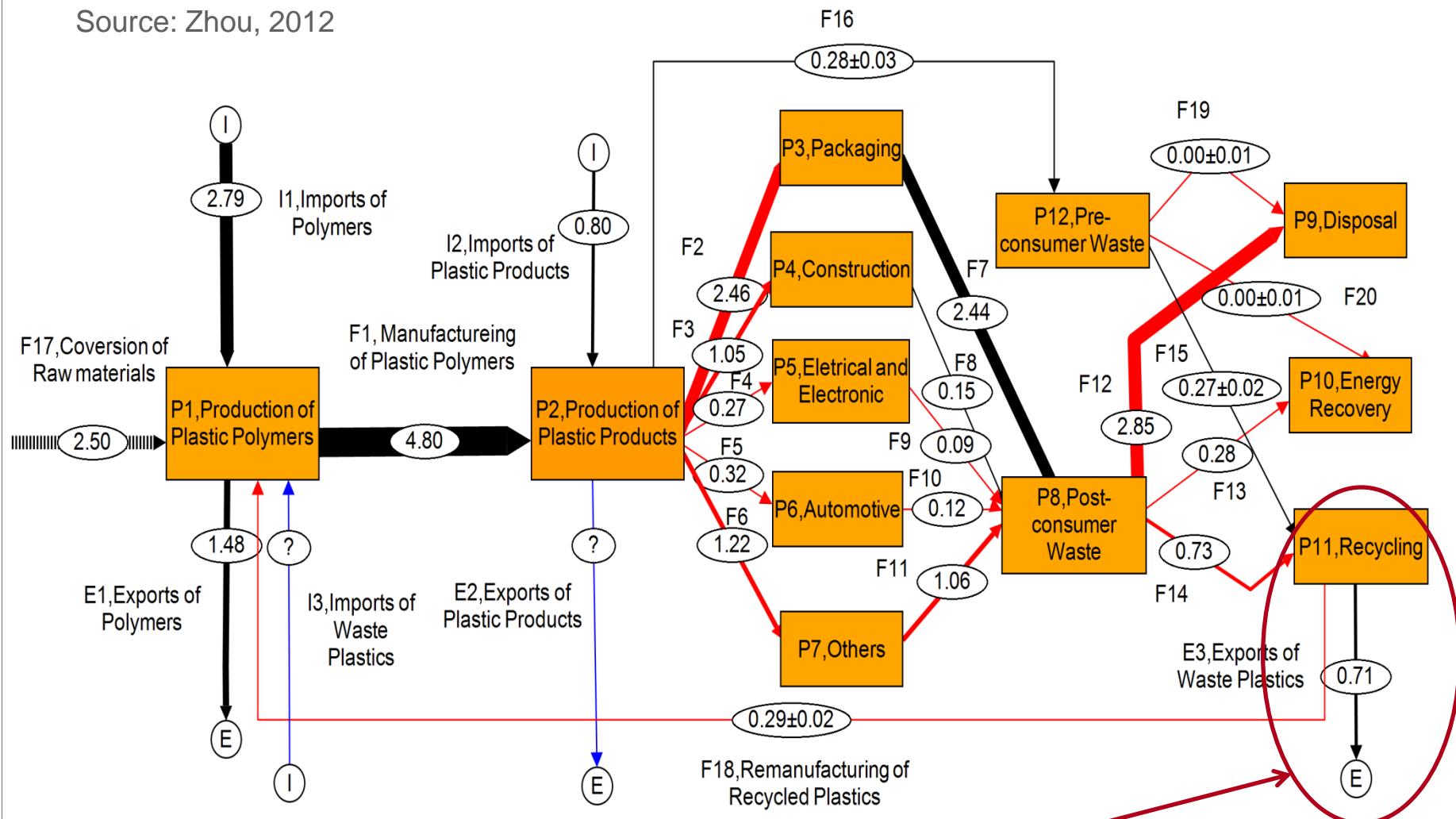
- Outside Europe countries: negligible contribution

# Waste plastics flows in the UK and... beyond Reprocessed for export?



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Source: Zhou, 2012

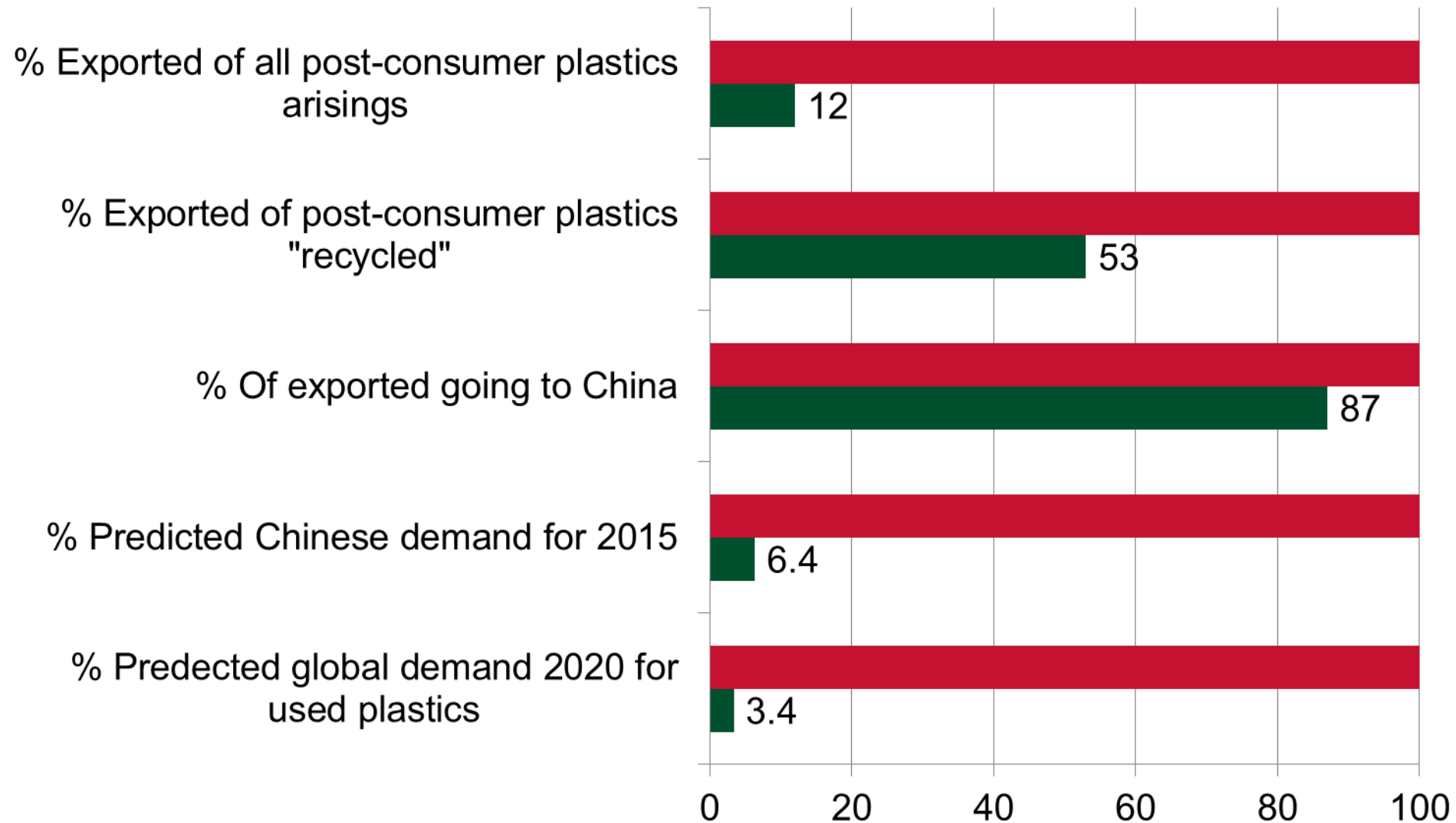


Around **70%** wt. of “recycled” UK plastics are exported

# EU-27 used plastics comparative analysis (3.4 Mt of exports)



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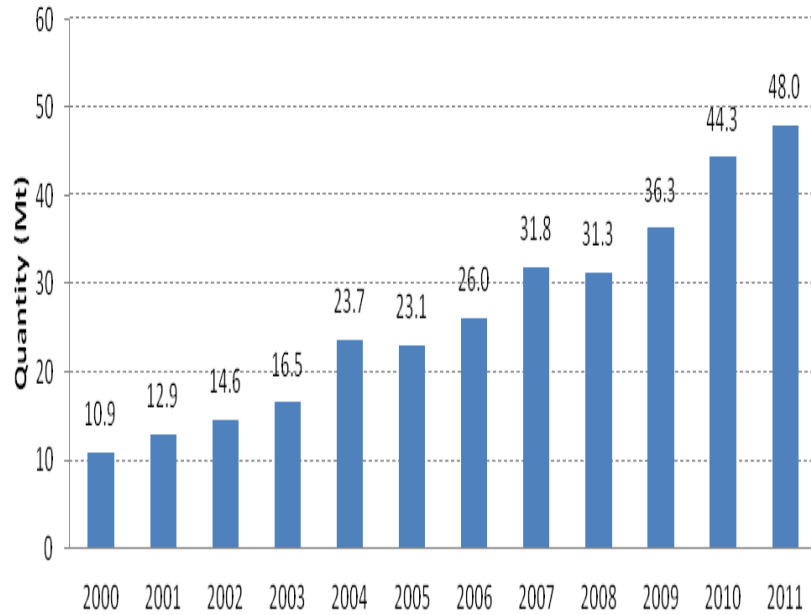




# What happens within China?



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**Oligospony:**  
**56% wt. of worlds' imports**  
**goes to China**

**High consumption and hence**  
**demand for polymers**  
**(primary and secondary)**



# China: in high demand of (waste) plastics



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- ▶ **China in top consumers of plastics:** plastic products consumption grew rapidly from 22kg per capita ( $\text{kg p}^{-1}$ ) in 2005 to 46kg  $\text{p}^{-1}$  in 2010 (Liao, 2011).
- ▶ **Chinese domestic supply: inadequate to meet demand**
  - Almost half of primary material is imported
  - Total yearly imports of primary plastics covering just less than 50% of total demand (2011: 23Mt)
  - Dependency on imports of one commodity should not exceed 50%
  - Reduces Chinese dependency on primary plastics imports
- ▶ **Prediction for 29Mt plastic scrap demand by 2015** (China + HK – Source: Poyry, based on CBI China projections)
  - Europe now exports: **3.4Mt**

# 3 possible destinations within China



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“3-non enterprises”: **no rules for operation**  
– **no quality standards** – **no inspection**

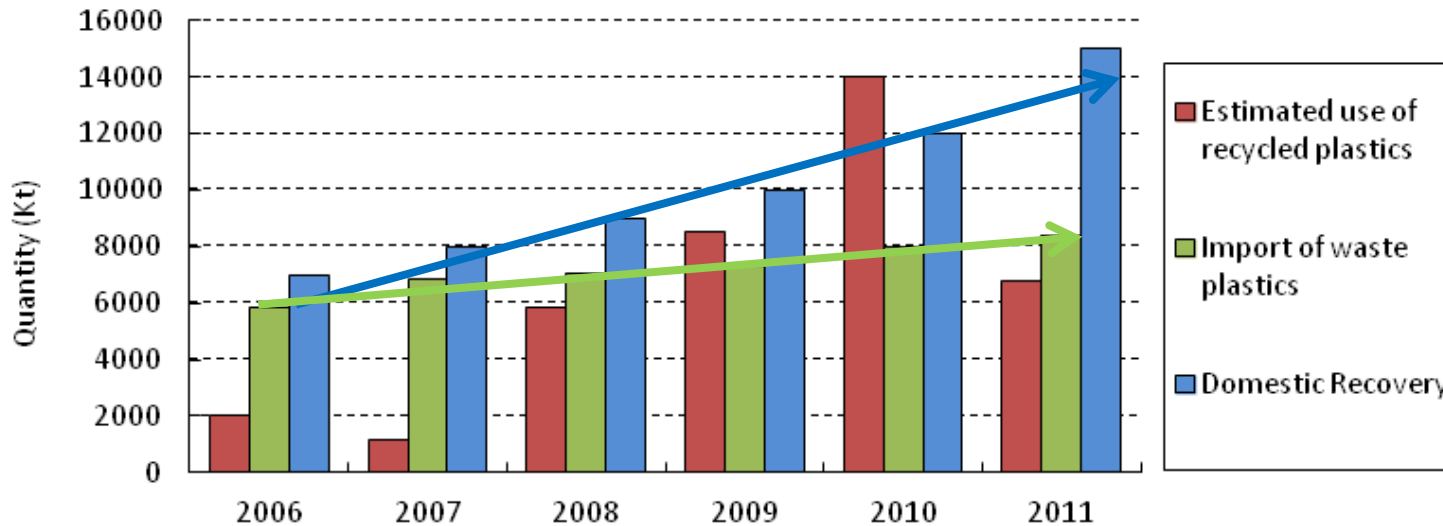
**Big centralised reprocessing facilities**

**Incineration / energy from waste?**

# Estimated use of recycled plastics in China



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Source: Zhou, 2012

► **Data-sets not fully mutually consistent** (use of recycled plastics and total recovered plastics)

- **Domestic recovered plastics: almost twice as imports in 2011**
- Despite that recycling of domestic waste plastics is still very low (But: **target for 70% recycling set!**)
- 2006 and 2007: use of recycled plastics lower than imports

# Fate of imported waste plastics in China?



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- ▶ **HYPOTESIS: Quality of imported plastics scrap is higher than domestically obtained (or perceived as such)**
  - Imports needed due to quality better than domestic Chinese sources
- ▶ **Following HYPOTETHES:**
  - Most / best of imported used for new plastics production
  - Worst of imported / best of domestic ends up in 3-nons
  - Most of domestically collected material ends up in EfW?
- ▶ **Plastics reprocessing in China: Wide spectrum of industry**
  - Three ‘non’ enterprises” - Mainly small-scale, family owned; **low-tech manufacturing practices**; very low / no environmental protection
  - Most products: **low quality for own Chinese affordable consumption**
  - Manufacturing / export of **counterfeit goods?**

# Documentary on reprocessing plastic scrap imports “Deadly waste in China”



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5000 plastic recycling companies in the province of Shandong



See at 2DF: <http://www.zdf.de/ZDFmediathek#/beitrag/video/1993090/Die-Doku:-Tödlicher-Müll-in-China>

# Documentary on reprocessing plastic scrap imports “Deadly waste in China”



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**See at ZDF:** <http://www.zdf.de/ZDFmediathek#/beitrag/video/1993090/Die-Doku:-Tödlicher-Müll-in-China>

# Recycled in China in 3- non enterprises - implications for resource recovery?



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Around **70%** wt. of “recycled” UK plastics are exported: **IMPLICATIONS?**



*“A Chinese woman holds her baby as she strips labels from plastic soda bottles so they can be recycled.”*

Copyright: Peter Ford/The Christian Science Monitor. After (Ford, 2013)



*“Coal fired extruder in a small recycling plant in China.”*

After (Jefferson 2010)



*“Children sorting out tiny specks of wrong colored plastic chips. Many hundreds of bags await their eyes and fingers.”* © BAN. After (Pucket et al., 2002)

- ▶ Variable manufacturing practices: High use of additives + low quality products
- ▶ = **down-cycling + increased pollution of materials cycle**
- ▶ Poor worker health and safety
- ▶ Environmental protection not a priority criticised for absence of environmental standards (**China Plastics Scarp Association**)



# Efforts to improve: Quality controls implemented at China's customs:



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## **‘Green Fence Operation’ is rapidly changing import facts**



Photo by Dan Kitwood/Getty Images – Web  
source: WONGBLOG (Plumer, 2013)

- **“Green fence operation”** : enhanced enforcement campaign implemented at Chinese customs
- Since February-October 2013
- It implements **legislation on quality** of imported waste-derived secondary raw materials.
- 2009 Chinese regulations allow up **only 1.5% wt. physical contamination**



## International recycling markets for plastics scrap - complex interplay of:

- (1) National (domestic) solid waste collection capabilities** (formal and informal), reprocessing capabilities and needs, and export /transport laws and controls.
- (2) Market demand and import controls at major destination countries** (e.g. China) and investment in raw material production elsewhere (e.g. Chinese investments in Africa).
- (3) Global supply chain networks:** transport logistics and costs (westbound freight rates, number of empty containers returning to Asia (“reverse haulage”), customs).
- (4) Cost of primary resins, dependent on oil and natural gas prices** (prime determinant of the price of recycled plastics)
- (5) Technological innovation:** (new resins, composites, oxo-degradable and compostable plastics, sensor-based sorting, chemical recycling).
- (6) International and domestic politics** (price dumping? – economic growth and employment generation – “green economy”)

# A least environmental standards pathway?



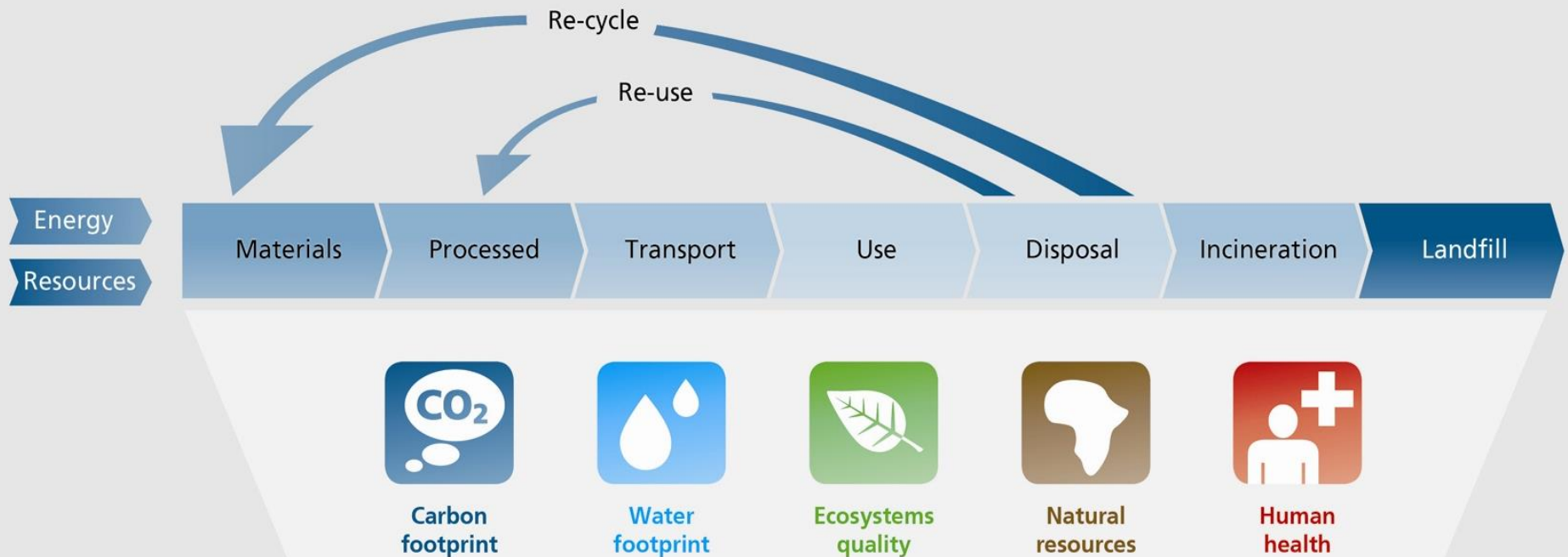
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- ▶ **Least environmental standards / resistance path is often followed**
  - Applies to waste trafficking (e.g. WEEE)
  - Same for global waste and secondary raw materials trans-shipment?
  - Support for hypothesis: (1) Hong Kong and China (2) role of ASEAN countries (3) reaction to Green Fence Operation
  
- ▶ **? A direct link between:**
  - Western consumption patterns and
  - Small-scale low-tech reprocessing enterprises in South Asia?
  - Negative correlation between **amount of exported waste and wages in importing countries** (D'Amato, Lozzi et al., 2012)

# Life cycle assessment: some challenging outcomes



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LCA evidence that plastics recycling over performing EfW  
**only if virgin polymer is replaced above 70-80%**  
(Rajendran, Hodzic et al., 2013)

# Challenges with plastics recycling via exports



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A complex and potentially vulnerable market: exporters need help – fight illegal trade

China oligospony – huge EU dependence

Poor environmental control and H&S, and sub-optimal manufacturing practices in China

General pathway of least environmental performance – risk transfer

E.g. dispersion of PoPs vs. destruction in EfW?

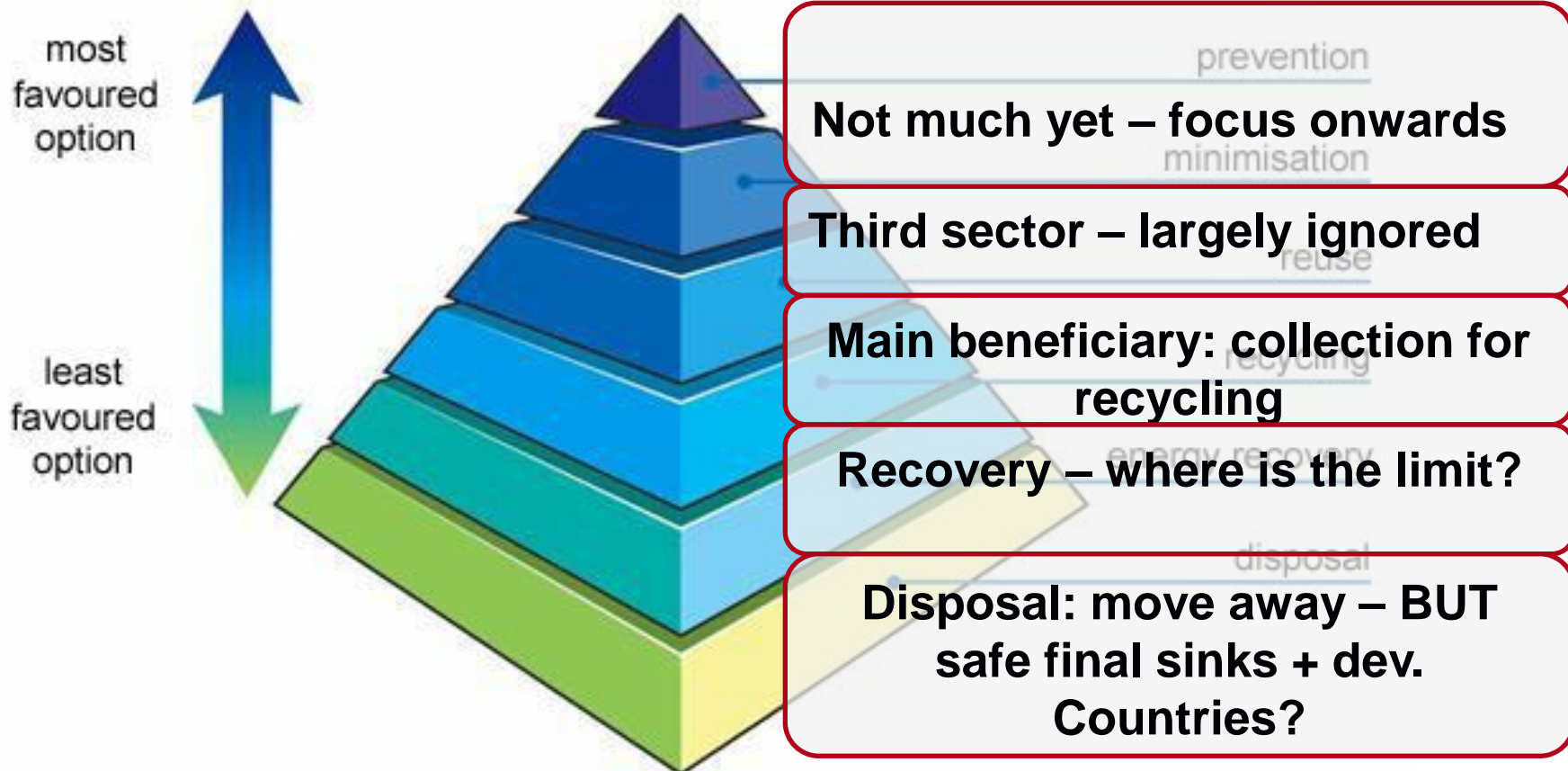
Environmental aspired benefits may not materialise: need for transparency - traceability

Lost of opportunities for high value recovery: closed-loop recycling, local green growth and energy generation under optimal conditions

# Waste hierarchy according to revised WFD: 2008/98/EC Directive (Art. 4)



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Source: <http://www.ehsgs.com/company-ethos.html>

At best: just a static “environmental” hierarchy of waste processing options: simplistic >> simple?

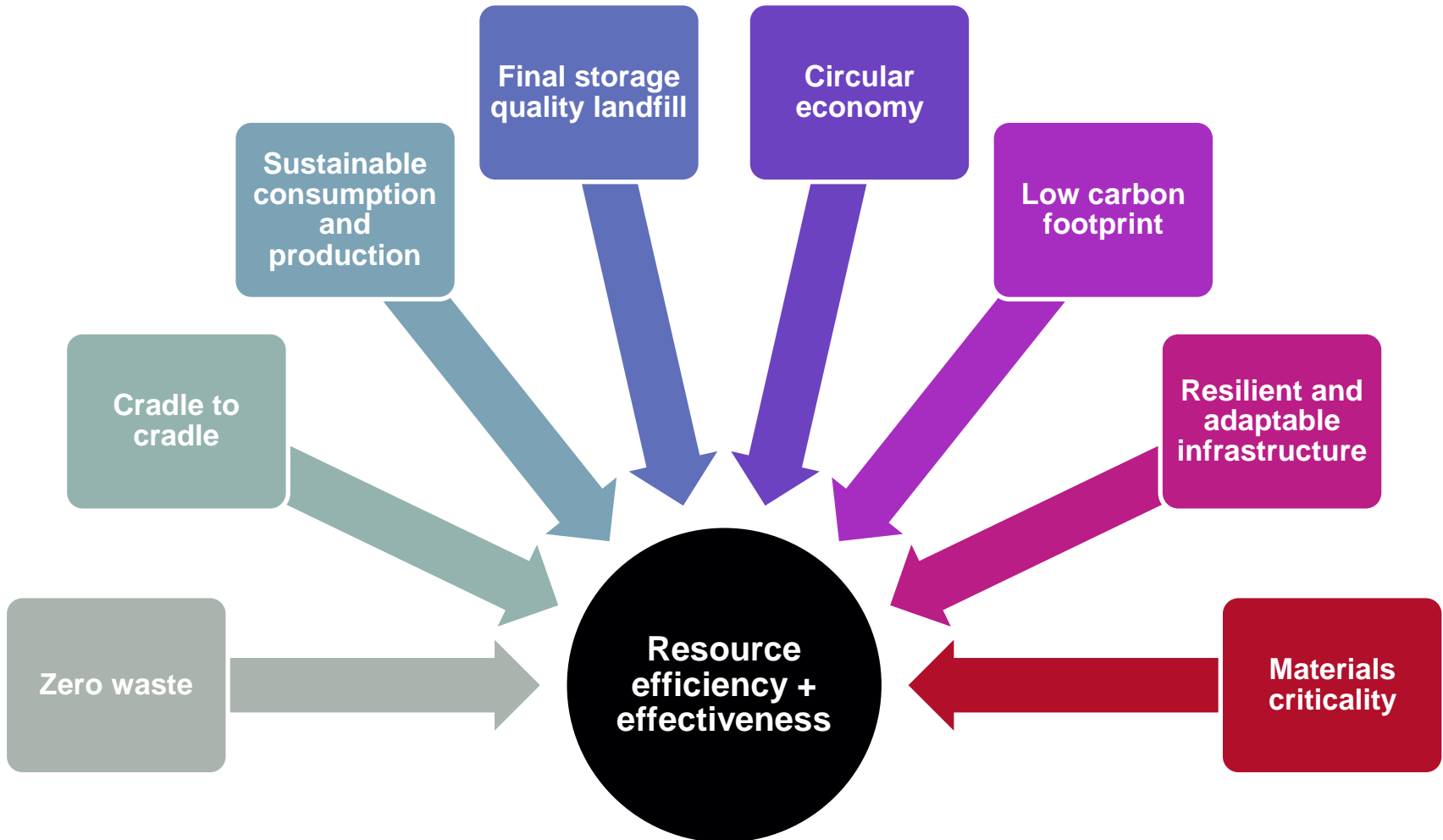


- **1990: poor recycling levels for EU 12 MSs** municipal waste recycling rates
  - Ranged from **1 to 20% wt.**
  - Half of 12 MSs between <1 – 6% (Source: Environmental Resources Limited:1992)
- **Today: High recycling rates (40% or more) achieved** – targets set
  - Benefits of technical and bio-based (green) materials recycling / recovery rediscovered
  - Invested heavily in physical infrastructure and communication strategies
- **A resource efficiency motivation?**
  - **Not primarily driven by commodity value of recovered materials**
  - Recycling market as a competitive 'sink' - alternative to increasingly expensive landfill disposal and EfW

# Recycling markets – which future model?



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# Roadmap to a Resource Efficient Europe (COM (2011) 571)



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## REALITY

*“In some Member States **more than 80% of waste is recycled**, indicating the possibilities of **using** waste as one of the EU’s key resources”*

“Recycled” is connected to “using” – is it the case??

How to define / measure?

## 2020 aim

*“Energy recovery is limited to **non recyclable materials**, landfilling is virtually eliminated and **high quality recycling is ensured**”*

How to ensure / evaluate?

## 2020 aim

*“More materials, including materials having a **significant impact on the environment and critical raw materials**, are recycled”*

Differentiate based on materials criticality / impacts

# R1 EfW formula: defining the line between recovery vs. disposal

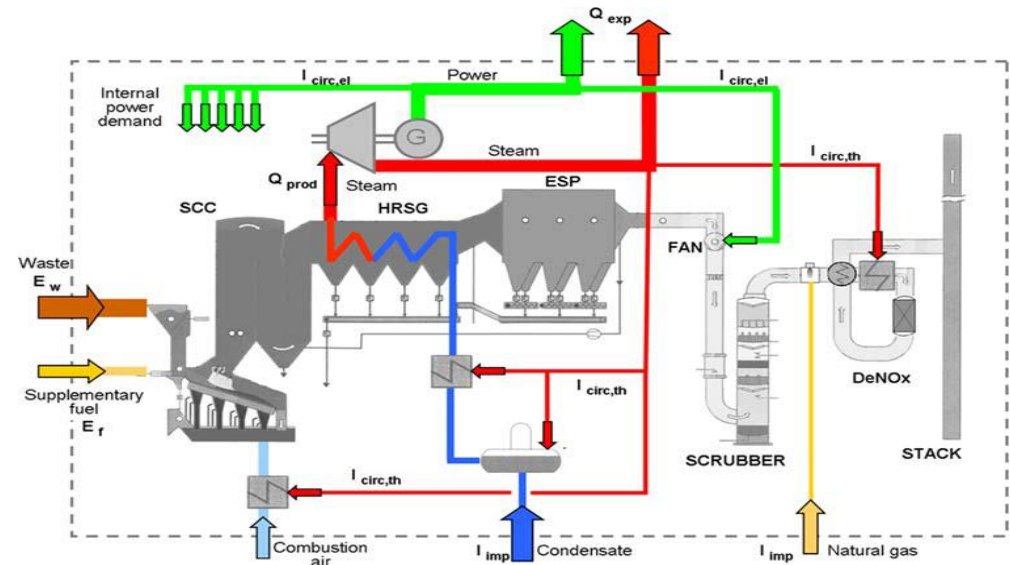


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$$R1 = \frac{E_P - (E_f + E_i)}{0.97 * (E_w + E_f)}$$

- WFD 2008/98/EC: allows efficient EfW facilities to be classified as 'energy recovery' operations
- **Single most important development**
- **Systems and measurable outcome** focused approach



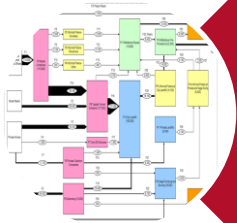


- ▶ **No evaluation at all:** E.g. as the EfW is leading the way to quantifying efficiency and quality via R1 and biogenic content measurement
- ▶ **No quality**, no material criticality, no systems / overall resource efficiency **considerations for recycling**
- ▶ System boundaries? **MRF input** vs. **virgin material substitution?**
- ▶ Closed loop and down-cycling **count the same**
- ▶ **Overestimation** by considering rejects as “recycled”
- ▶ No **traceability – transparency**
- ▶ **Export often for down-cycling?** – human health and environmental risks?

# Is waste hierarchy outdated in a globalised recycling system?



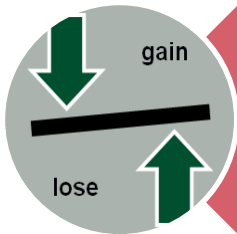
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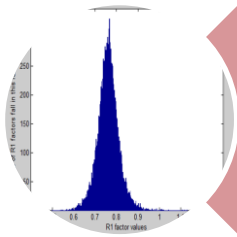
No systems - boundaries



No multiple aspects of value



No trade-offs



No optimisation

# Quality of recycling: real sustainability benefits



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- **Need to ask the right questions to inform the way forward**
- Focus on truly sustainable and high value (e.g. PET close loop)
- Transparency – traceability – quality controls before exports
- Establish a maximum acceptable environmental cost for recycling
- Focus on clean material cycles and prevention of pollution dispersion
- Higher ambitious intangible generic recycling targets will increase the materials collected: **are we creating a hot potato and for whom?**
- Should we move out of **inertia** and use “**priming**” in this debate?
- Why not use targets / measure much more **downstream**?
- Quality quality quality?
- **Quantify quantify quantify**

# Recycling operation modes: future focus on actual sustainability outcomes



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Recycling  
business as  
usual  
**High  
unverifiable  
collection  
numbers**

Collected for recycling-  
exported for???

No metrics – poor data  
–low confidence

No End of Waste –  
quality management

Multiple closed loop and  
down-cycling equal

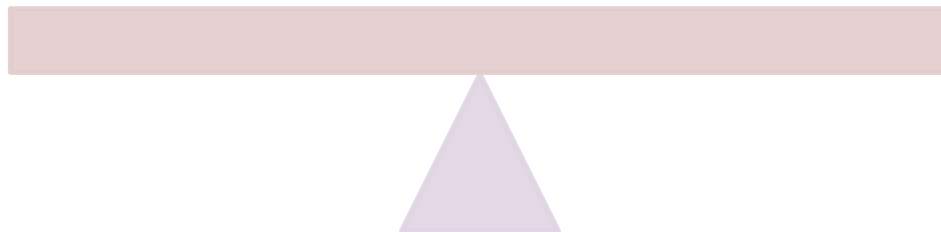
Systems holistic  
approach – scientific +  
policy metrics as R1  
EfW

Clear quantification of  
contribution to resource  
recovery

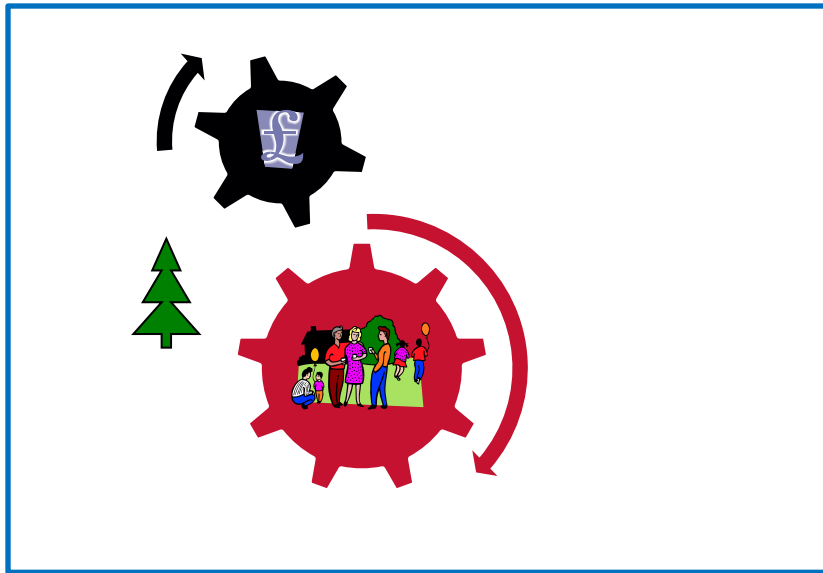
Meaningful waste  
hierarchy level  
distinctions

Lower recycling  
numbers – more  
tangible benefits

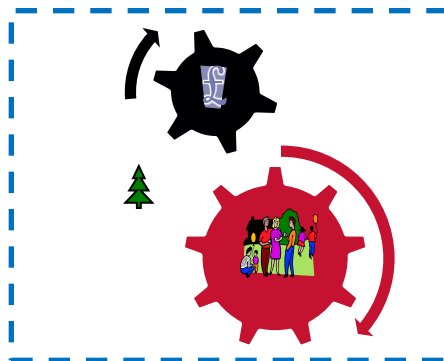
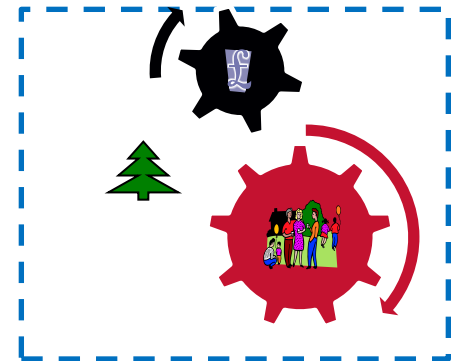
Recycling for  
resource  
recovery  
**Quality and  
impact  
orientated  
Systems  
optimisation**



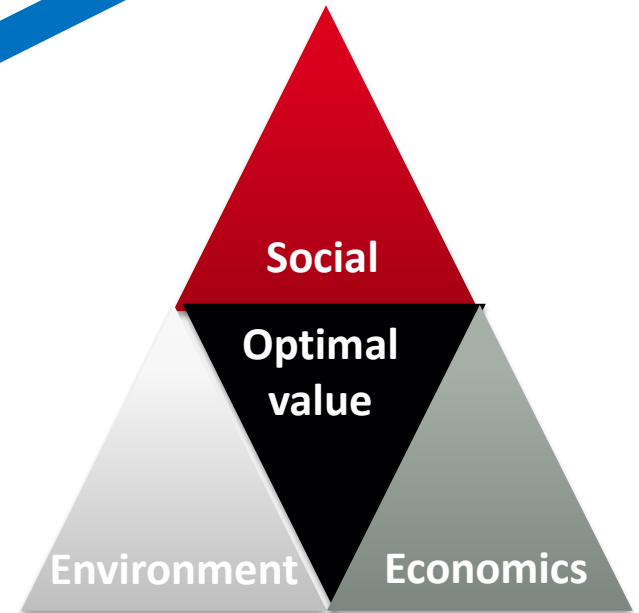
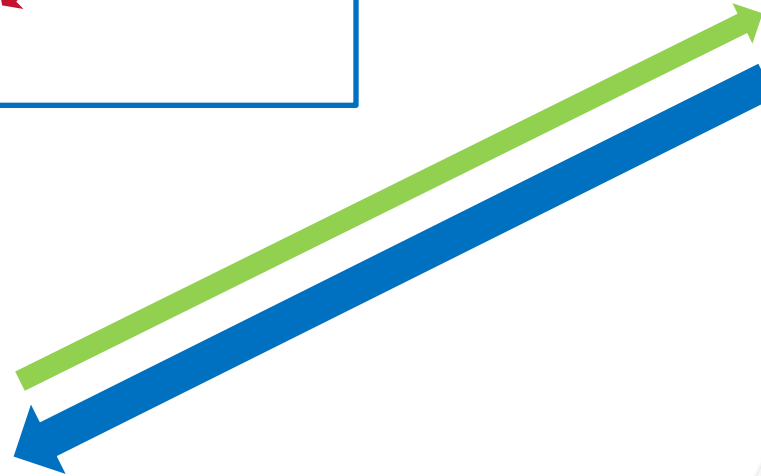
# System A



# System B



# System C



# Complex Value Optimisation of Resource Recovery



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**“If you cannot measure it, you cannot manage it”**

**C-VORR at University of Leeds:**

**Please join our efforts**

**for an evidence-based**

**circular and green economy**



# Global plastic recycling markets ISWA report info in the UK press



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theguardian

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Environment > Waste

## China leads the waste recycling league

EU legislation is fuelling a multibillion-dollar market. As landfill charges increase, it is often cheaper to send rubbish abroad

Kara Moses  
theguardian.com, Friday 14 June 2013 15.56 BST



Waste from Europe, including paper and plastic, is often sent to China to avoid landfill costs. Photograph: Kim Kyung-Hoon/Reuters

theguardian

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Professional > Guardian Sustainable Business > Hubs | Events | A

## Resource efficiency hub

From Guardian Sustainable Business

## Could China's 'green fence' prompt a global recycling innovation?

Beijing's crackdown on substandard recyclable waste has caused chaos for some western waste exporters

Katharine Earley  
Guardian Professional, Tuesday 27 August 2013 12.37 BST  
[Jump to comments \(3\)](#)



e-efficiency

Thank you!



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**ISWA**

*International Solid Waste Association*



*European Economic and Social Committee*

**Employer's Group**