

# BAUXITE RESIDUE VALORISATION AND BEST PRACTICES CONFERENCE

Leuven

5-7 October 2015



# Bauxite Residue: Harnessing Open Innovation and Effective Communities of Innovation and Practice

Bauxite Residue Valorisation and Best Practices Conference  
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Professor Jeremy Howells  
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profjhowells@gmail.com

# Outline

1. The Problem
2. The Response So Far
3. Moving Forward
4. Analysis
5. Next Steps and Basic Tenets
6. Conclusions  
Principles

# 1. The Problem: I

- There is a lot of bauxite residue left as a result of mining for aluminium
- Some good solutions have been developed towards using bauxite residue in new and different ways from....
- .... re-mining for rare earth minerals, towards the development of new materials and through new ways to environmentally ameliorate residue build-up



# 1. The Problem: II

- However not nearly enough to resolve the problem with reserves of over 3 billion tonnes of bauxite residue and the inventory growing at 150 million tonnes per annum....
- .... and not helped by being in a highly cyclical industry
- Big swings in demand and prices and....
- ... therefore the resources and willingness to resolve the problem

## 2. The Response So Far: I

- There have been a whole raft of technically focused initiatives to address the problem and can be grouped in various ways.
- However primarily from an **economic outputs and outcomes** focused perspective they can be classified under 3 main groups:
  1. Residue minerals
  2. New products
  3. 'New' (reclaimed) land

## 2. The Response So Far: II

1. **Residue minerals:** Re-mining or technospheric mining of residue encouraged by the fact that they have been rising in price and supply security or new technical processes have made the residue minerals more attractive to rework, especially rare earth minerals (particularly scandium) but also pig iron, titanium and alumina (Binnemans et al., 2015)

## 2. The Response So Far: III

2. **New products** arising from recycling and reworking:
  - i. basic building materials (cement, bricks, etc. (Pontikes and Angelopoulos, 2013));
  - ii. mineral wool (with pig iron from Greece); and,
  - iii. other materials (e.g. Alcoa's Red Sand™)
3. **Land:** Improved environmental remediation of former resided areas to be used in former or new land uses



## 2. The Response So Far: IV

.... but we could add a fourth, intangible:

4. **Reducing the ‘environmental debt’**: helping to ameliorate or remove a problem whose full economic costs are hidden and, in some circumstances, not fully captured or attributed to anyone (issue of negative externalities and the problem of the ‘economic commons’)

## 2. The Response So Far: V

- Good, but....
- despite hundreds of patents and thousands of trials have been issued and undertaken on bauxite residue use and some of these applications have been commercialised...
- “... it no way nears matching the tonnage arising annually with possible commercial applications... and has been, and continues to be, a major challenge.” (IAI, 2015)

## 2. The Response So Far: VI

- Clear progress on specific technical solutions...
- ... but these are limited given the scale of the problem and remain piecemeal and hampered by **commercial pressures** (prices, performance, risk profile, etc.; Klauber et al., 2011)
- **Complexity** in these issues, not just true for bauxite, but mining in general: “Research on extraction methods and composition of technospheric stocks is of continued interest. Such knowledge is necessary for any mining activity, but at the same time, it denies the true complexity [...of technospheric mining]”  
Johansson et al. (2013)

### 3. Moving Forward: I

- Complicated and messy
- Not just technical issues and
- ... not just about acknowledging commercial concerns and the need to recognise (and cost) the wider externalities of bauxite residue but...
- ... also recognition there needs to be wider work on the **socio-technical and institutional 'architecture'** needed to effectively address the bauxite residue problem

## 3. Moving Forward: II

Key is to create a:

1. resilient, open system
2. that does not close down opportunities or pathways
3. that allows new or additional streams of innovation in relation to red mud to be made - crucially retaining diversity of opportunity

### 3. Moving Forward: III

4. recognises that research groups and companies have started to develop real solutions around the problem of red mud that provide specific commercial opportunities in its exploitation and these need to be retained for the system to remain inclusive...
  5. ...above all it needs to be global in reach.
- Requires an **open industrial ecosystem** in relation to innovation in this area



## 4. Analysis: I

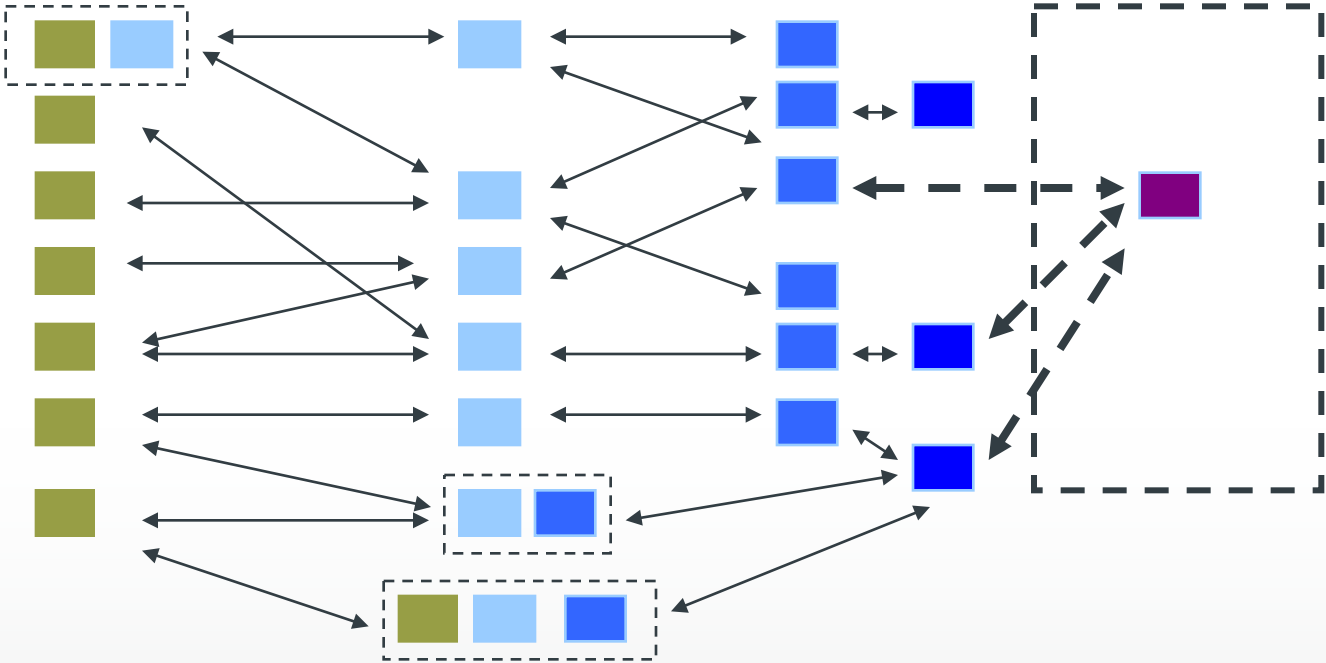
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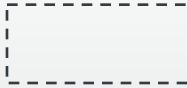





- understand the Bauxite-Alumina-Aluminium Industrial System
- the range of different actors (firms, universities, public agencies, etc.) within it
- chart, map and measure the system architecture

(Stage 1)

# Bauxite-Alumina-Aluminium Industrial System

1



-  Integrated company
-  Bauxite mining company
-  Aluminium smelting company
-  Aluminium manufacturer
-  Final manufacturer
-  Final consumer

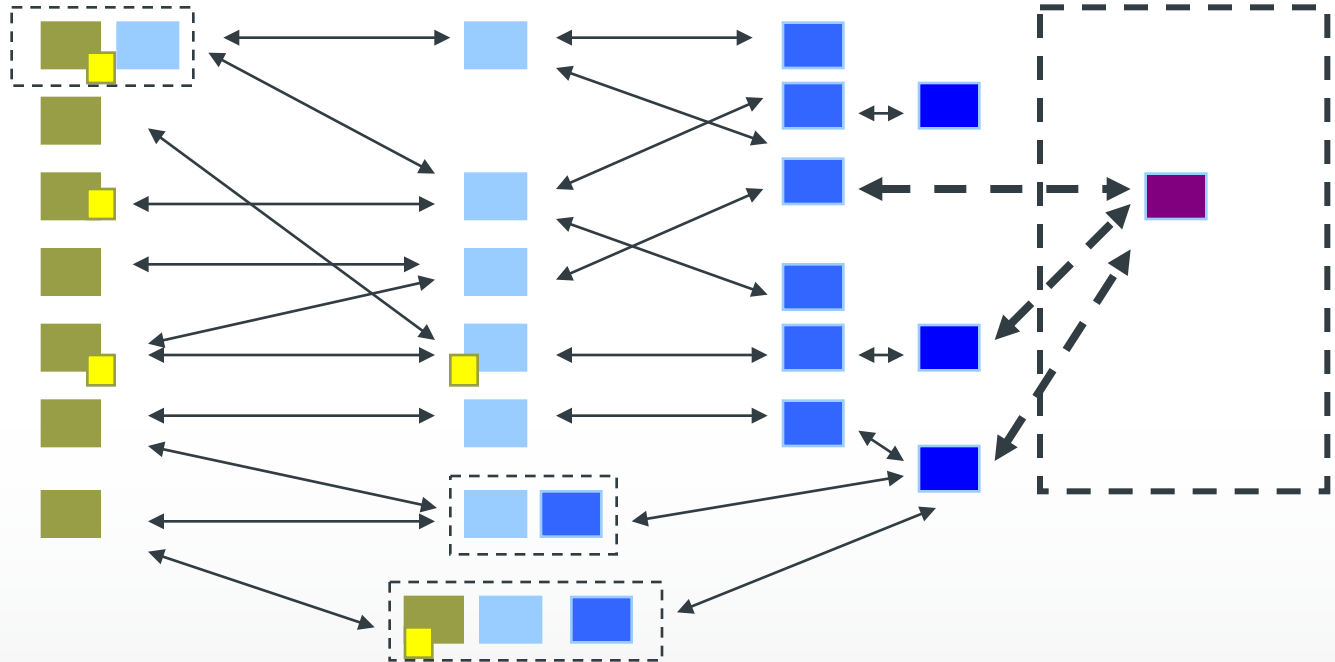
## 4. Analysis: II

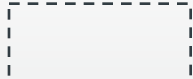






- However in the context of bauxite residue, we have a further, more specific innovation (sub) system around resolving the issues of red mud
- ...and what might be termed **Technospheric Innovation Projects (TIPs)**...
- that combine both technological innovation but also non-technological innovations for their commercial success and development

(Stage 2)

# Bauxite Residue Innovation System

2



-  Integrated company
-  Technospheric Innovative Project (TIP)
-  Bauxite mining company
-  Aluminium smelting company
-  Aluminium manufacturer
-  Final end manufacturer
-  Final consumer

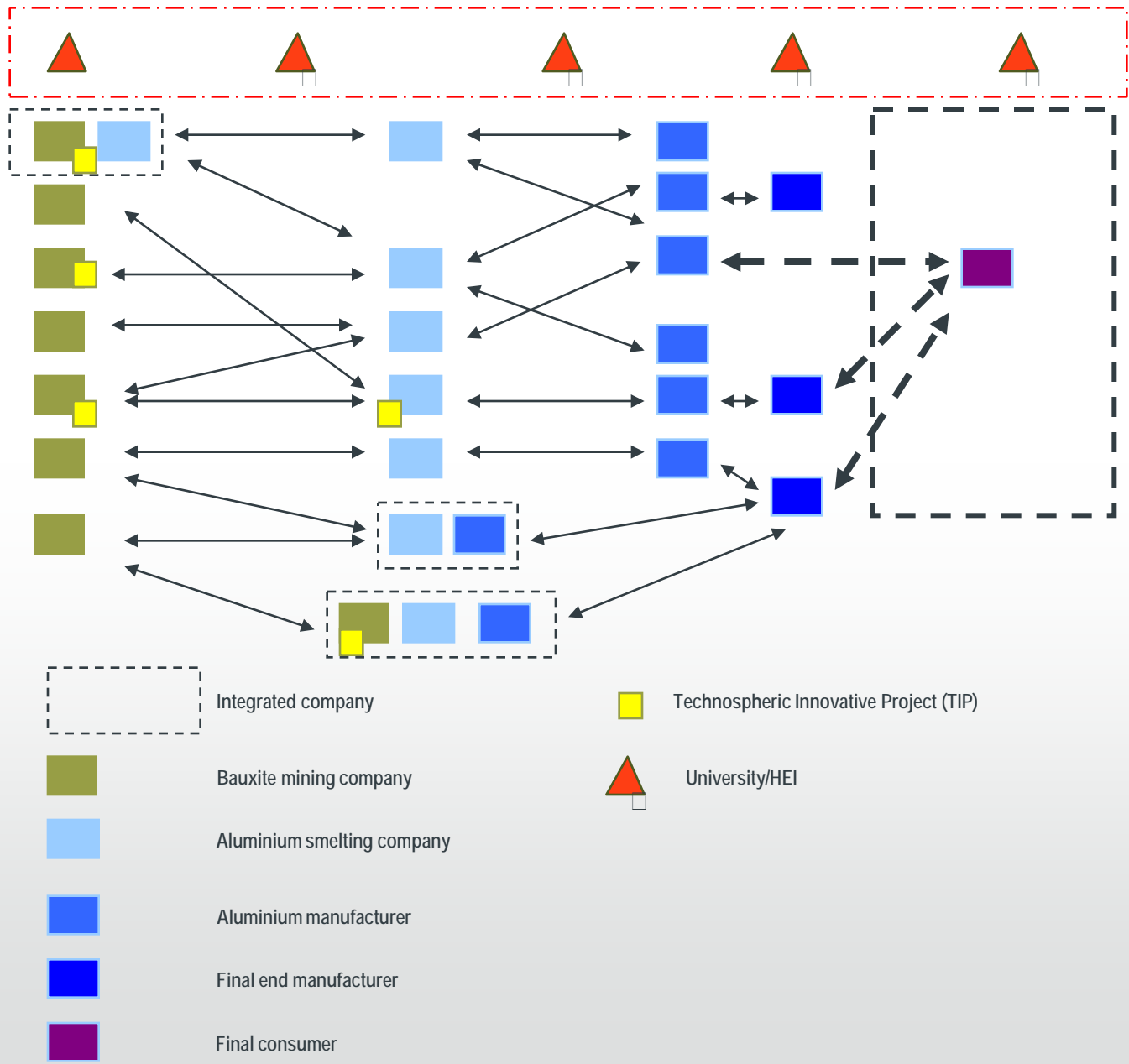
## 4. Analysis: III

- However, wider research system involved with...
- Universities and other Higher Education Institutions (HEIs) as key actors that support both basic and applied research in the companies in the system (e.g. CSRP) and...
- are often centrally involved in the development of the specific TIPs

(Stage 3)

# Bauxite Residue Innovation System

3





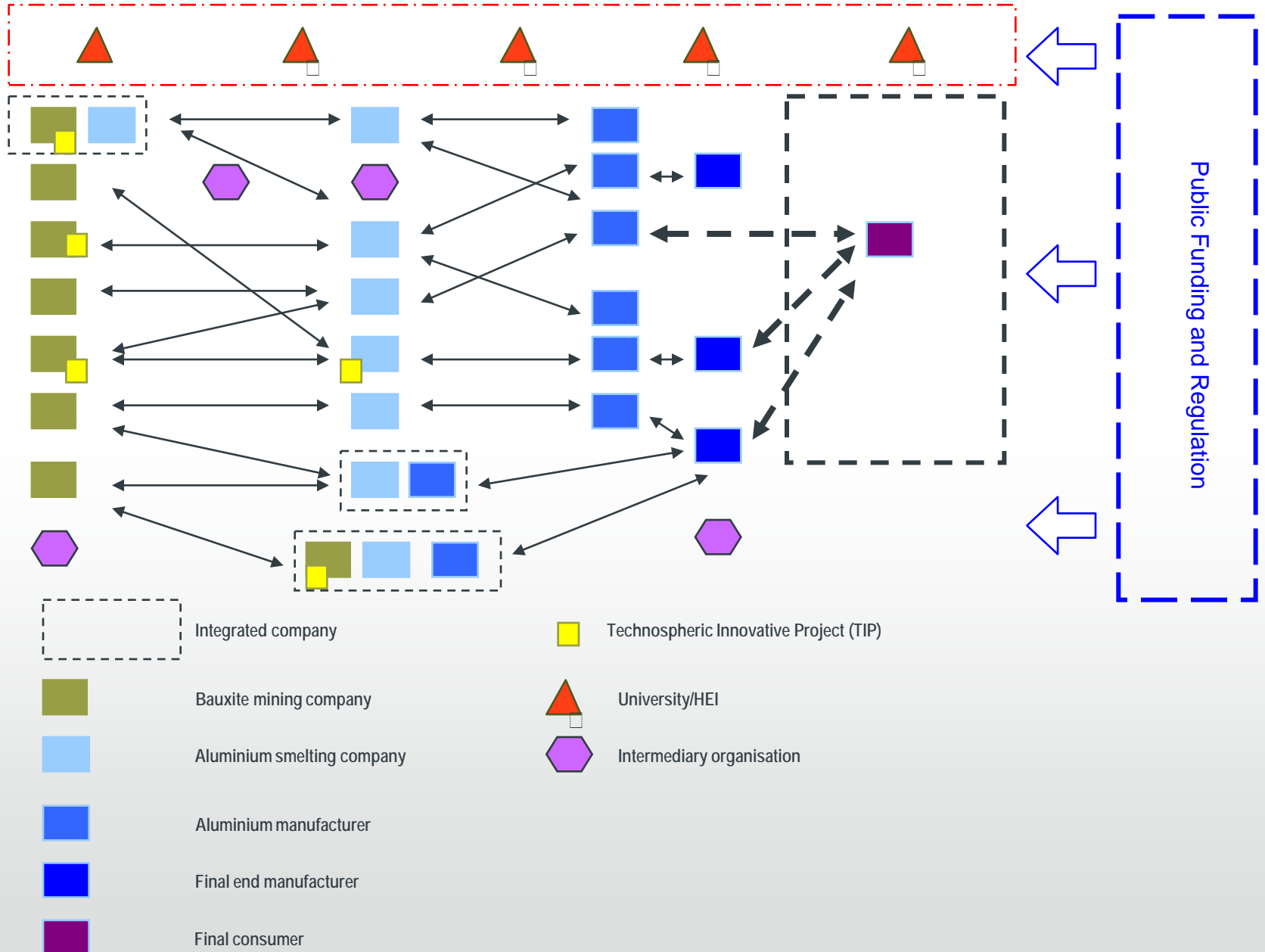
## 4. Analysis: IV

- Lastly, the all important intermediary organisations in both international (such as IAI, CR<sup>3</sup>, ICSOBA, EA) and national (such as AA and CNIA) in scale..
- ... and the funding (such as EU projects - BRAVO) and regulation around dealing with red bauxite that goes with it
- A crucial role here are the intermediary organisations and identifying the range and influence of them

(Stage 4)

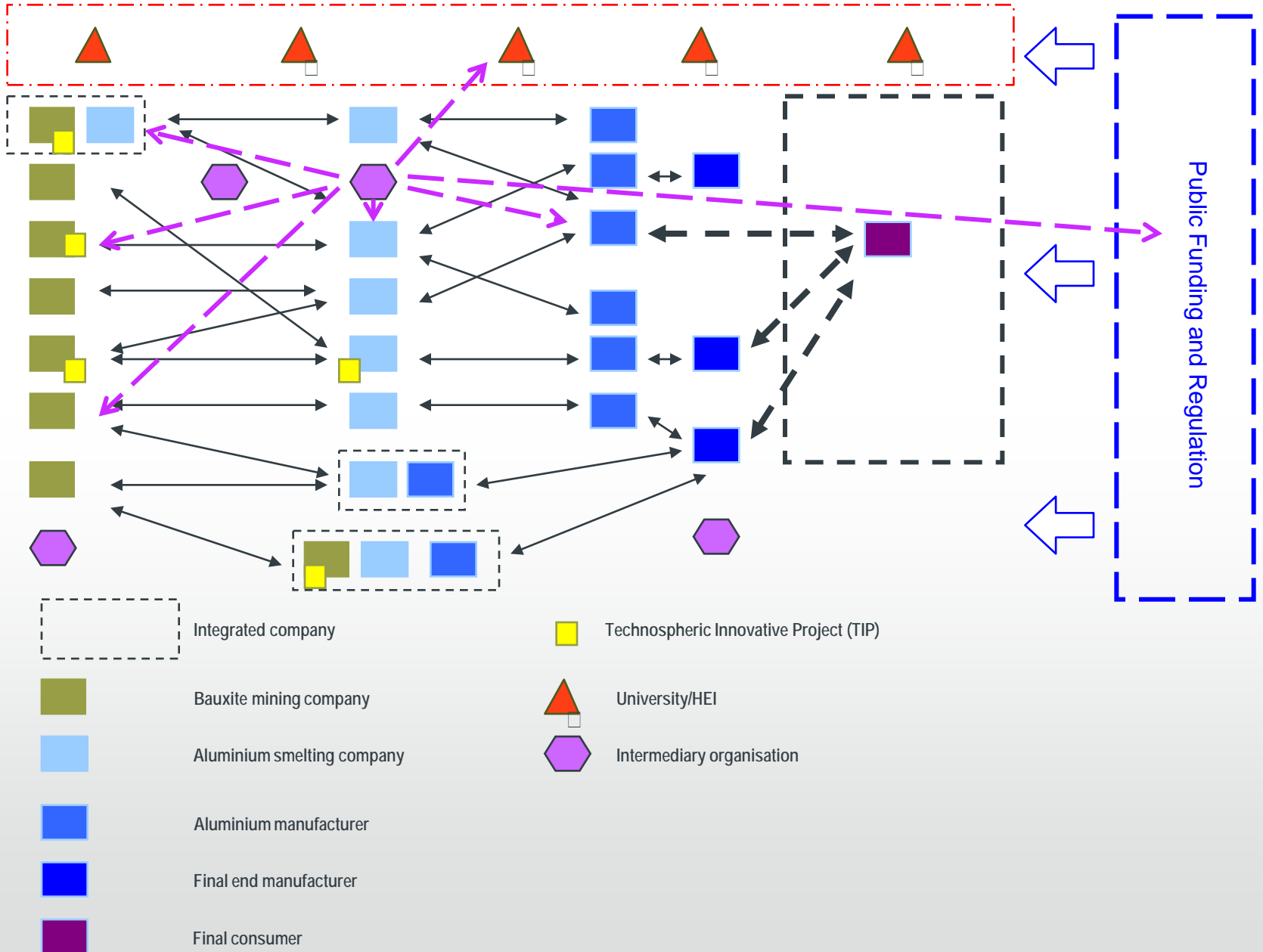
# Bauxite Residue Innovation System

4



# Bauxite Residue Innovation System

4



## 4. Analysis: V

Mapping and measuring of the (sub) system non-trivial exercise and needs to be focused on:

- **Links:**
  - need a “better understanding of the material flows”
  - obtaining a “full view of world flows and life cycles of materials” in the system and links
- Understanding of **knowledge exchange** and repositories also clearly required:
  - around “new types of knowledge” in the system
  - gain knowledge from companies and countries with high expertise (e.g. mineral processing in Australia and Canada)
- **Actors** and actor roles

## 5. Next Steps and Basic Tenets: I

- What does this all mean? Where do we go from here?
- Analysis is all important
- Need for new and different perspectives
- What elements do we need in the framework?
- Here are some....

## 5. Next Steps and Basic Tenets: II

1. Needs to be **inclusive and global**:
  - need to the “involvement of state run companies”
  - UN organisations
  - intermediaries: not just non-profit organisations, but need to involve a range of public-private, public and private organisations that undertake intermediary type functions within this system



## 5. Next Steps and Basic Tenets: III

2. To involve a more **holistic approach** to innovation: acknowledge that technological innovation in re-processing of residue will require innovation around the by-product itself and **non-technological innovations** in marketing, finance and sales
3. Requires a more **demand-led approach** to innovation and solutions encouraging 'pull' through of innovative, commercial solutions involving red bauxite; sustaining and creating new markets. This also includes incentive regimes (including standards and regulation)

## 5. Next Steps and Basic Tenets: IV

4. **The New:** stressed the need to include all types of actors, but we may need new types of specialised organisation and activities:

- i. **new actors:** re. ‘technospheric mining’ (Johanssen et al., 2013): one who owns the technospheric metal resources, another with the ability to collect and separate out the metals, and a third that has the capacity to recover the metal...

## 5. Next Steps and Basic Tenets: V

ii. **new platforms:** consortiums and coalitions (see Craps and Sips, 2010) and other types of collaborative mechanisms, especially:

- a) ***open innovation platforms***; and,
- b) ***crowdsourcing***

where all the actors can interact and share experiences...

# Unilever Open Innovation



Notable here:

- A key component of the platform is on innovation for sustainability
- .... growing its business whilst reducing its environmental impact
- Emphasis on defining “wants”
- Key recognition is around creating adequate markets for the solutions they are seeking

## 5. Next Steps and Basic Tenets: VI

### iii. new mechanisms and activities:

- recognise and encourage “***communities of practice***” in the field of bauxite residue innovation
- ‘***coopetition***’ recognising commercial competition but also advising ways of supporting a common agenda
- ***innovation competitions*** with an innovation prize (c.f. Longitudinal Prize £10 million) which help new partner formation

## 5. Next Steps and Basic Tenets: VII

5. Will require new and different kinds of actors, and mechanisms but wherever possible use, expand the remit of **existing actors**....
6. Retain **diversity of approaches**, respect commercial boundaries but to encompass this within a wider framework of sharing and cooperation
7. **Flexible and dynamic**: not a single ‘one-size fits all’ prescription to best practice bauxite residue management: “it involves managing each risk with best available technology appropriate to the circumstances” (IAI, 2013) and above all, a dynamic approach



## 5. Next Steps and Basic Tenets: VIII

- So need to recognise the whole system that forms the **Bauxite Residue Innovation System (BRIS)** and the **community of practice** already built up around it
- I believe intermediaries have a crucial role in the system and in leading any new initiatives
- However they need our support and we all have a role in the process

## 6. Conclusions

- Key is to start a dialogue and suggests a dialogue and overall framework to move on
- Ownership of the ideas important
- Work on issues around innovation and communities of practice...
- In this spirit created some principles for action

# Principles: I

- 1 The power of 10: It must be truly inclusive; aim to include top 10 Bauxite countries and top 10 mining companies
- 2 Dynamic in nature. It must not damage, indeed should support, individual companies and research teams own innovations and new technologies towards ameliorating red mud (retaining diversity and avoid 'lock in')
- 3 Allow the more rapid uptake of adaptive best practice activities across the world

# Principles: II

- 4 Should establish a global cooperative partnership to both spread existing technologies and best practices but also to develop new ones.
- 5 More emphasis should be placed on 'pull through', demand-led innovations and initiatives
- 6 It should establish an open innovation platform to share, such ideas and knowledge but also to encourage new ideas through crowdsourcing
- 7 Establish an annual competition with an innovation prize

# Principles: III

- 8 Should be both public (national governments through science councils, research establishments and technology transfer agencies) and private (miners/extractors, smelters, manufacturers and users) in nature
- 9 There should be a central organisation but also devolved units across the world
- 10 Need for clear incentives to undertake this and also regulatory and funding support (plus standards and accreditation)
- 11 Novel ways of funding the initiative need to be found

# Principles: IV

- 12 Need a supportive industrial ecology to support this innovation system (sub-system), binding in existing players and, where necessary, to create new players or intermediaries to support the process
- 13 Flexibility of approach and timing: accept at low end of pricing cycle (August 2015 \$1.55k per tonne c.f. 10 year high \$3.07k July 2008) but paradoxically may be good time to start