Japan's Strategy - Upcycling Phosphorus for Reducing its Supply Chain Risk in the High-Tech Industry

Hisao Ohtake

The director of the Phosphorus Industry Development Organization of Japan

The full-scale plant to recover P from incinerated sludge ash in Gifu City, Japan.

The alkaline leaching technology

From Mr. K. Goto, Gifu City Office

The recovered phosphorus products are sold to local fertilizer companies for recycling.

P_i fertilizing materials recovered from incinerated sludge ash

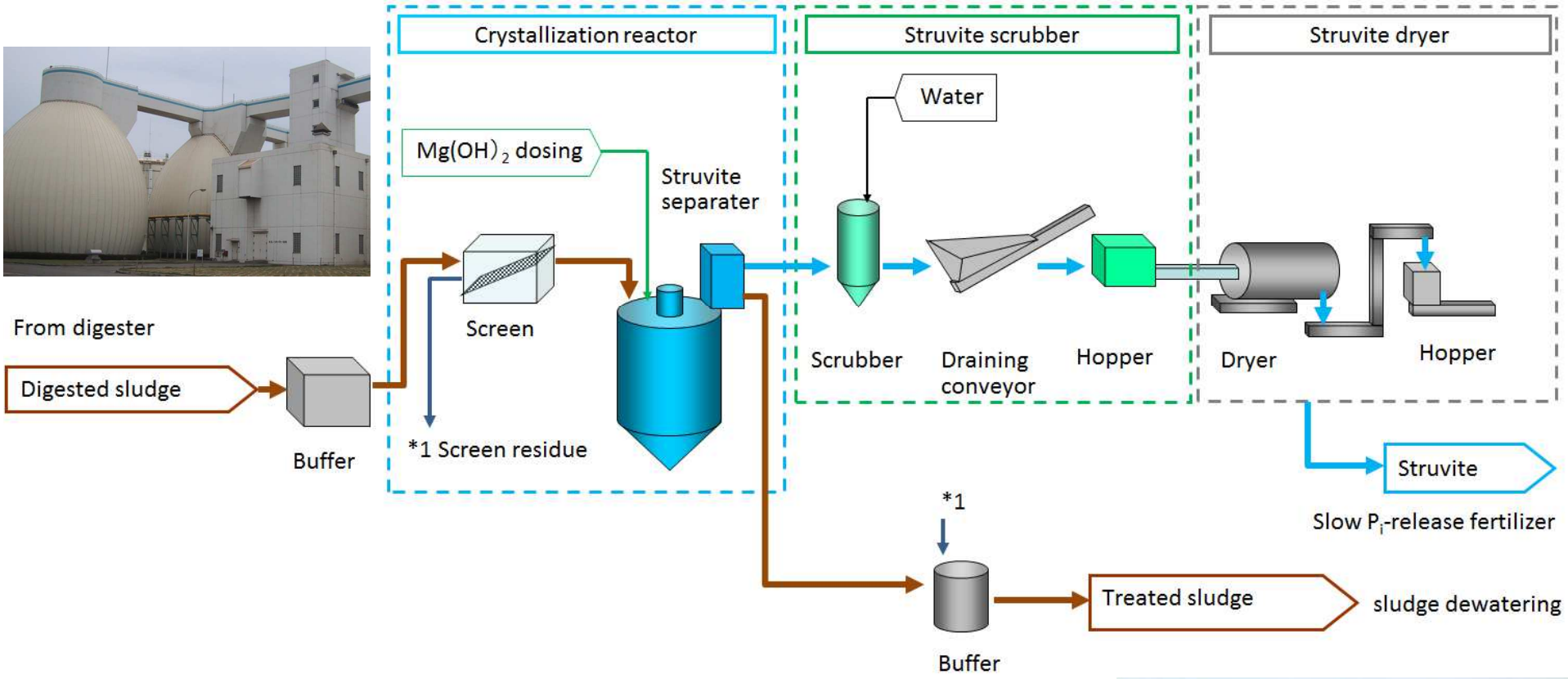
HAP

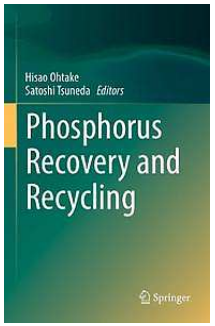
From Mr. K. Goto, Gifu City Office

Struvite recovery from anaerobically digested sludge at Kobe city

Recovered struvite is sold as a slow-release P_i fertilizer.

Swing Corporation





Struvite Recovery from Digested Sewage Sludge
D. Koga
Engineering and Development Division, Swing Corporation.

Challenges for operating P recycling business in Japan

Lack of sufficient policy support

and effective economic incentives.

⬇

No regulation for phosphorus recover

from waste and wastewater.

⬇

Little attention to phosphorus recycling.

PIDO

The use of recovered P product for fertilizer production alone is very difficult to make P recycling business economically feasible.

We need to have another complementary way for recycling P as a more value-added raw material in the high-tech industry.

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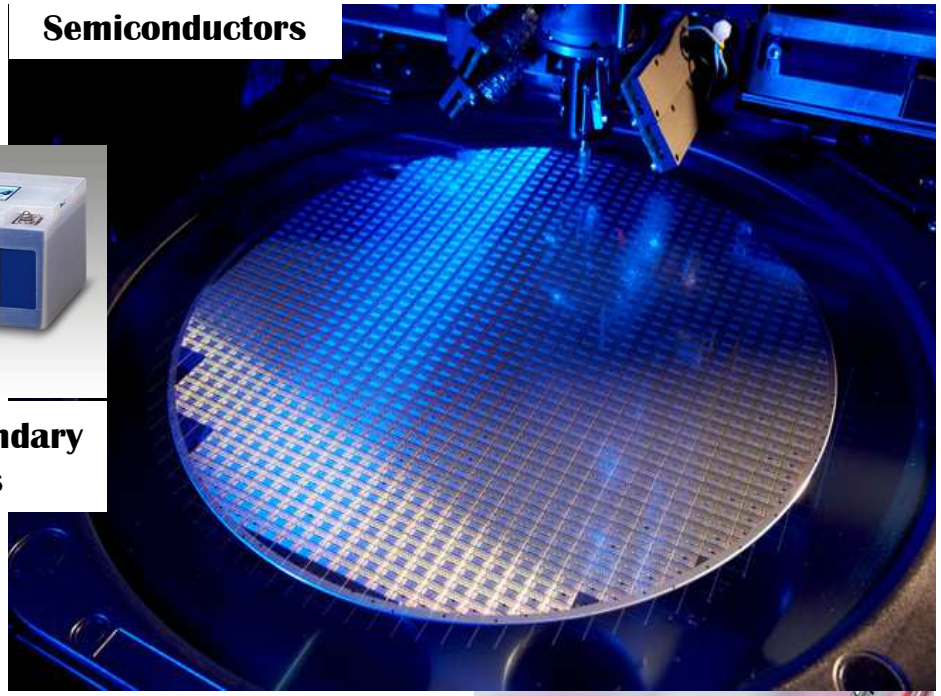
High-purity P compounds are strategically important raw materials in the high-tech industry.

Electric vehicles

Li^+ $[PF_6]^-$

Lithium secondary batteries

Semiconductors



Computers

Medical products
antiviral vaccines and PCR test reagents

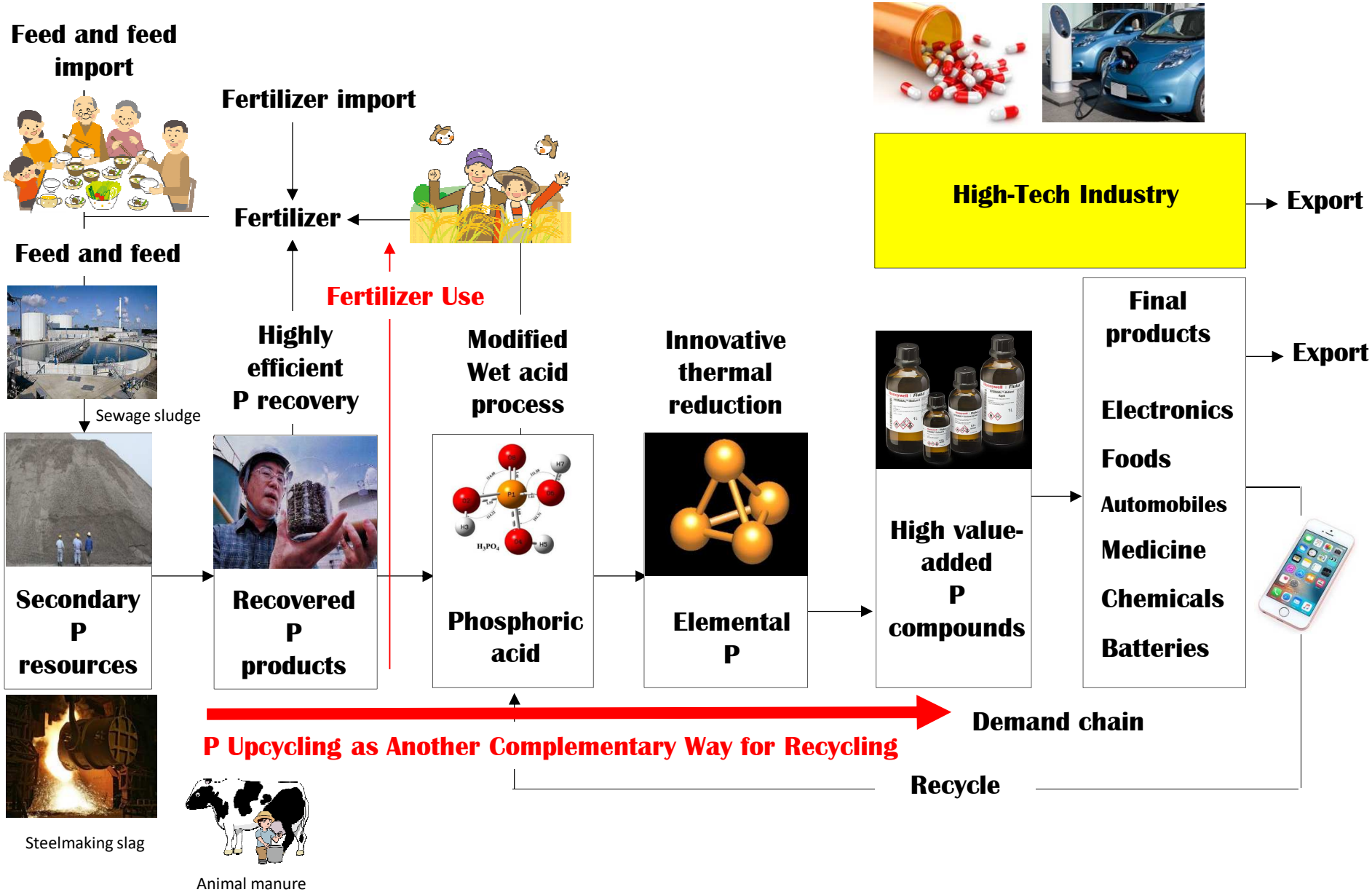
Photo https://www.webcartop.jp/2016/07/46162

Japan is very vulnerable to the risk of the phosphorus supply chain disruption.

To improve the resilience to the P supply chain disruption, we consider it critical to reshuffle the current P value chain through technology and business innovation.

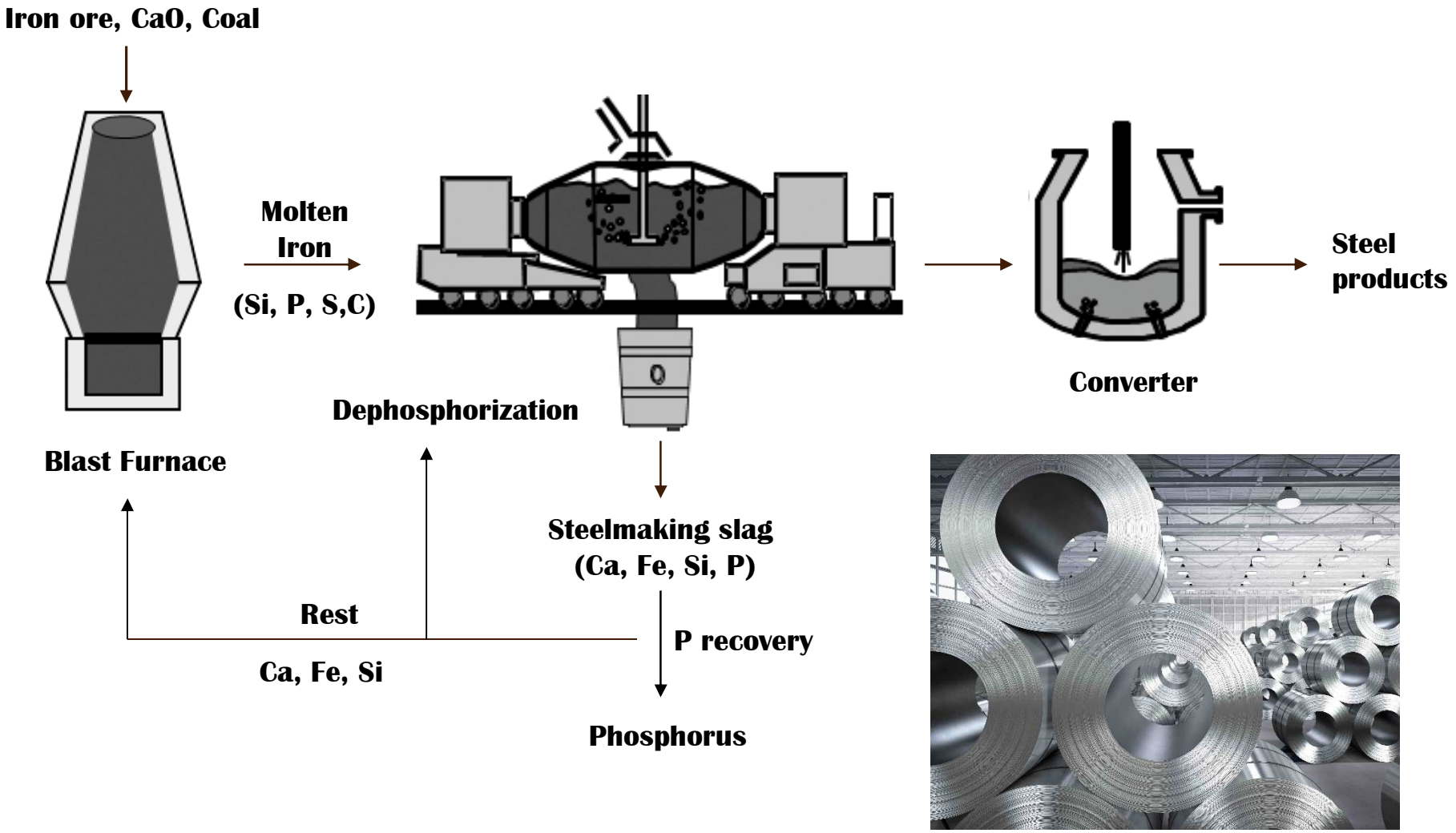
Shutter stock

Technology Innovation based on P recycling



Steelmaking slag is potentially the largest secondary P resource in Japan

P recovery from steelmaking slag can improve the resource efficiency of steelmaking process, while reducing the emission of CO_2.



From Prof. Tetsuya Nagasaka, Tohoku University, Japan

Unwanted steelmaking slag is now piled up in steelmaking factory yards!

The P recovery from steelmaking slag has the potential to supply two or three times more P than does the import of phosphate rock from abroad.

Attempts have been made to use recovered P for the manufacture of phosophoric acid.

Nippon Phosphoric Acid Co. produces merchant-grade phosphoric acid of 90 kt/y.

Wet acid process to generate phosphoric acid using incinerated sludge ash

Ash

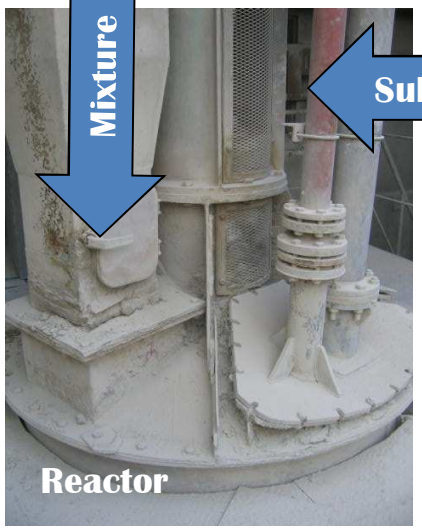
Ash

Ash

A maximum of 3% (w/w)

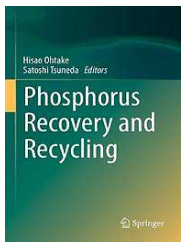
Mixture

Sulfuric acid



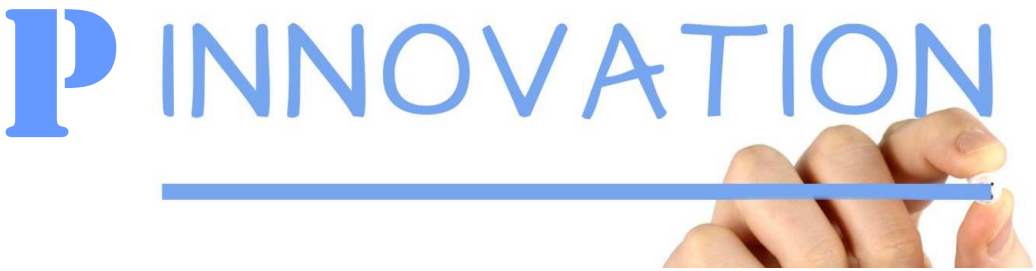
Phosphoric acid & gypsum

Phosphoric acid



PIDO

Innovation of elemental phosphorus manufacturing process



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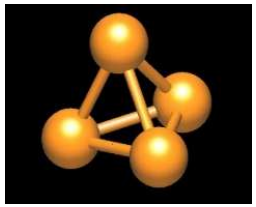

The production of elemental P is an energy-intensive process strongly depending on locally-sourced electricity.

Each ton of P produced requires about 14,000 kWh of electricity.

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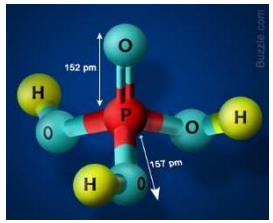
Environmental pollution is another challenge for the production of elemental P.

Innovative elemental P manufacturing with no P rock and less electricity

Recovered or recycled P compounds



Phosphoric acid

Liquid-type P compounds

Raw material processing ← Carbon

No toxic pollutants

Dry and heating

CO and H_2 fixation

Condenser

Precipitator

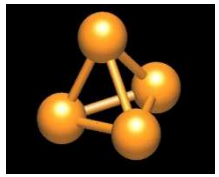
Reactor

$2H_3PO_4 = H_2(PO_3)_2 + 2H_2O$

$2H_2(PO_3)_2 + 12C = 2H_2 + 12CO + P_4$

900-1,000 °C

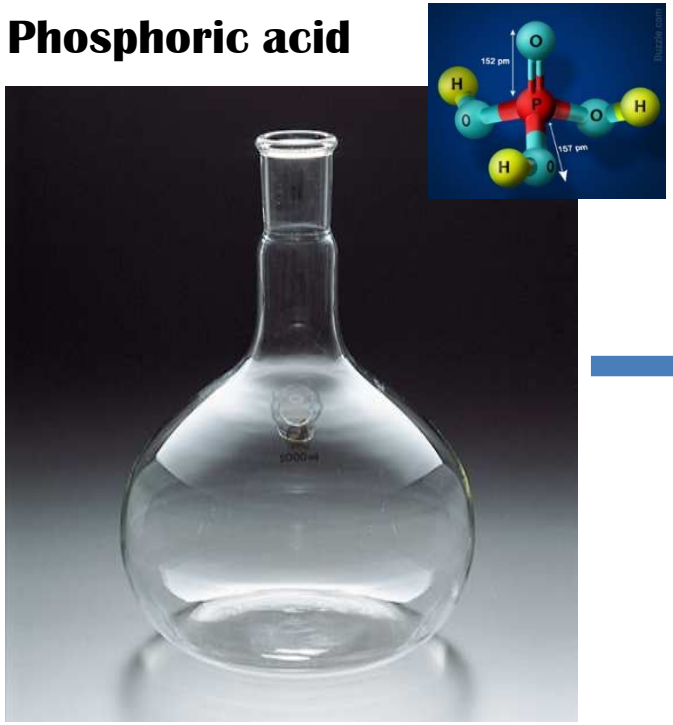
Storage tank

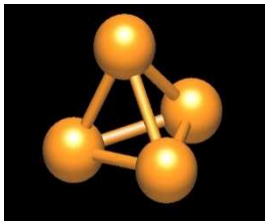


Minimum electricity consumption or no electric arc furnace

Initial test study was funded by the Japan Science and Technology Agency.

Phosphoric acid

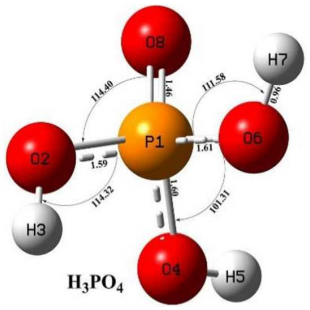


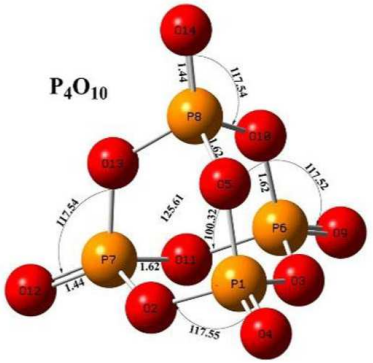


Elemental P

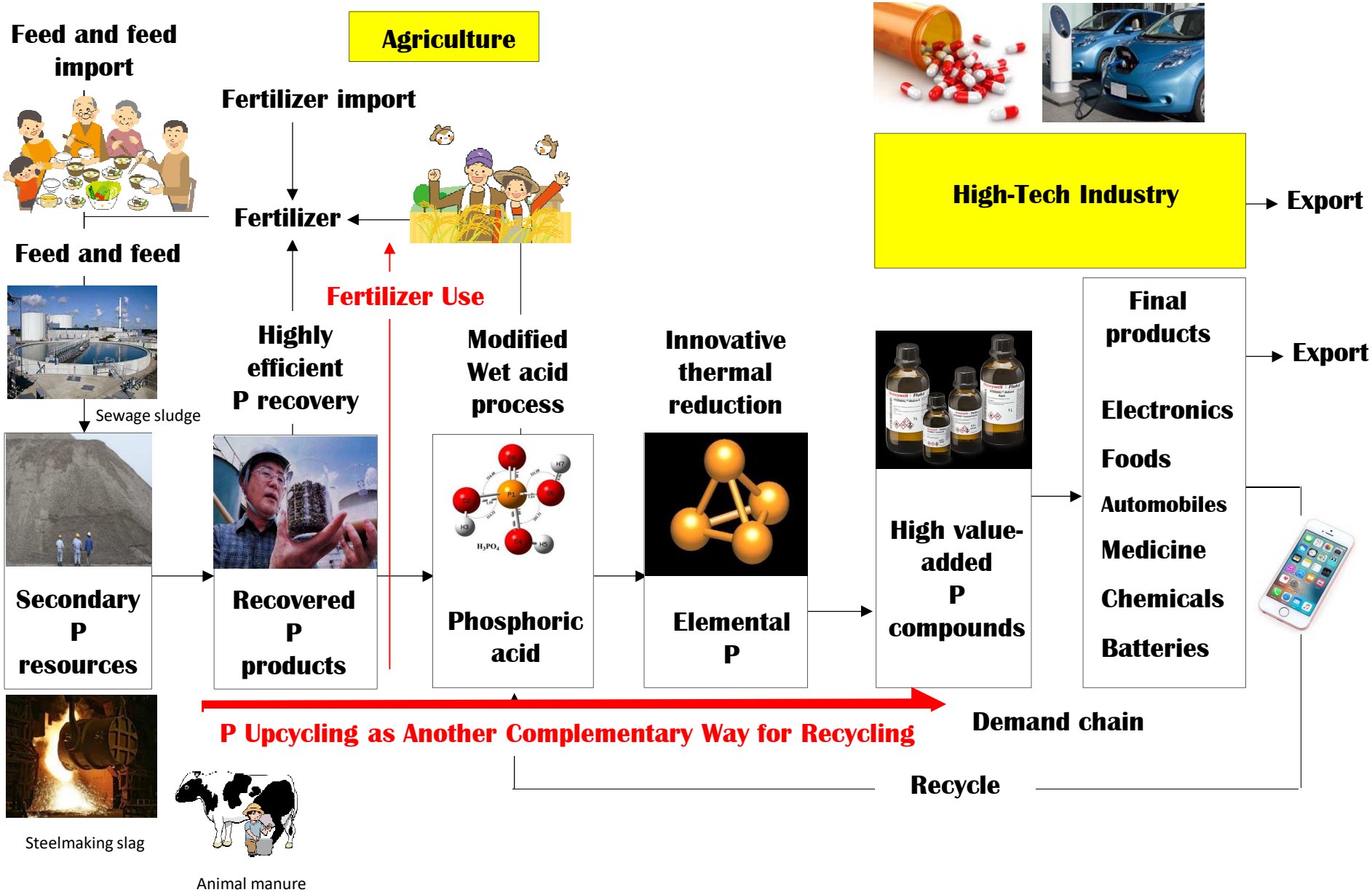
MIKUNI PHARMACEUTICAL INDUSTRIAL CO., LTD.

TOHOKU UNIVERSITY 東北大学





P upcycling strategy for expanding P recycling and reducing the P supply risk



PIDO

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Thank you very much for your kind attention and Goodbye !

University of Stuttgart, 7th October, 2014