# Innovative Circular Technologies for Harmful Nitrogen Compounds/ To Solve Planetary Boundary Issues

Project outline
Theme 3 R&D items and achievement

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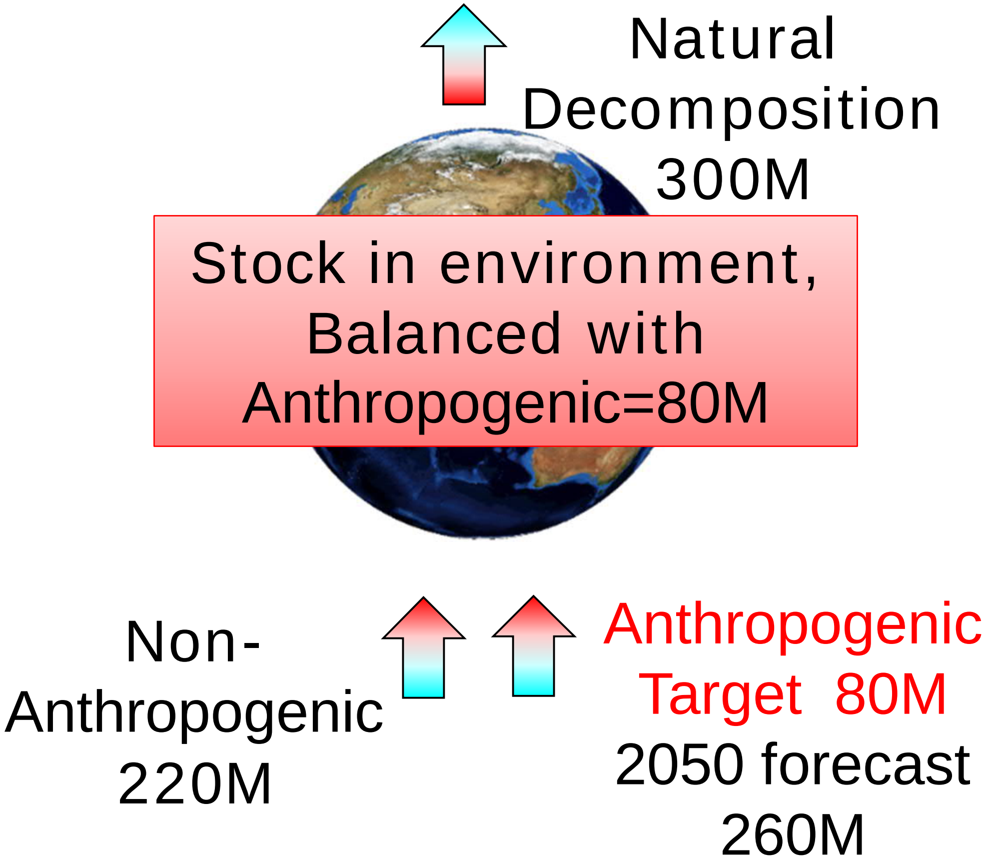
Implementing organizations : National Institute of Advanced Industrial Science and Technology (AIST),
The University of Tokyo, Waseda University,
Tokyo University of Agriculture and Technology, Kobe University,
Osaka University, Yamaguchi University, Kyowa,Hakko Bio Co., Ltd.,
ASTOM Corporation, Toyobo Co., Ltd., FUSO Corporation, Ube Industries, Ltd,

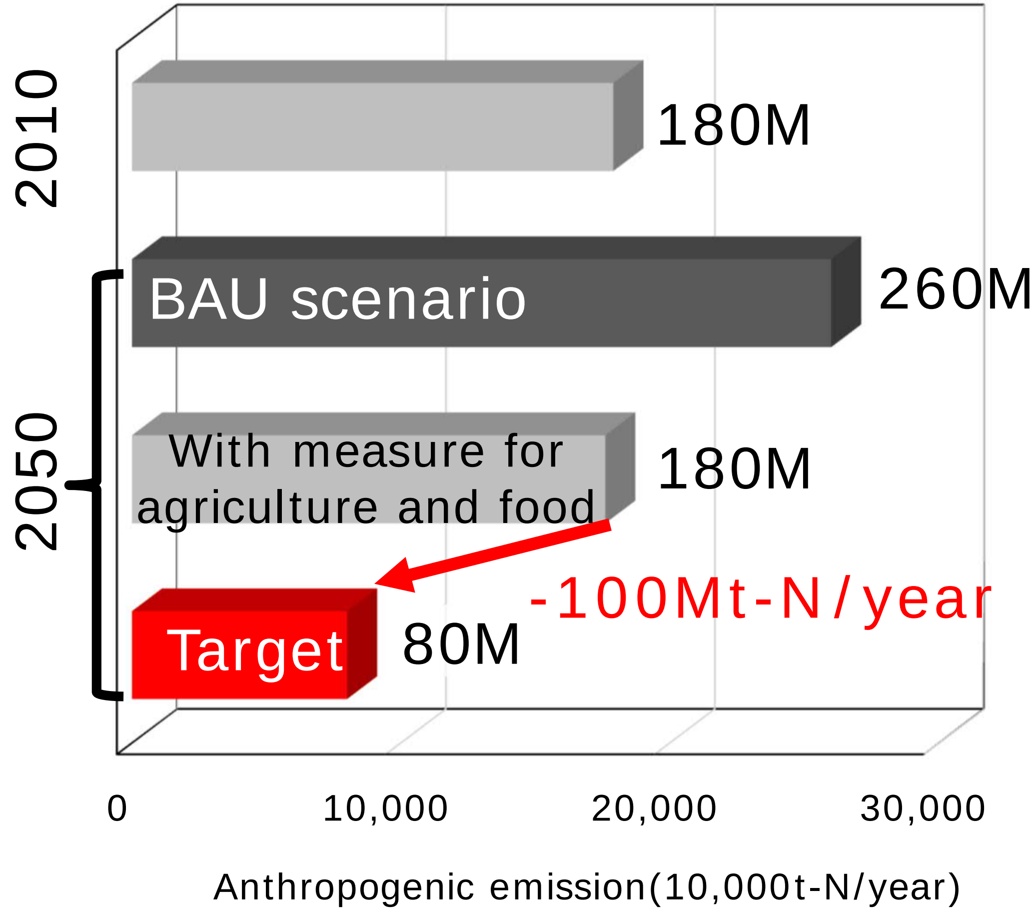
# Background of the project

(a)Target of Nitrogen compounds emission (t-N/year)




*Galloway, Biogeochem. (2004),*
*Fowler, Philos.Trans. R. Soc. B Biol. Sci. (2013)*
*de Vries, Curr. Op. Env. Sus. (2013)*

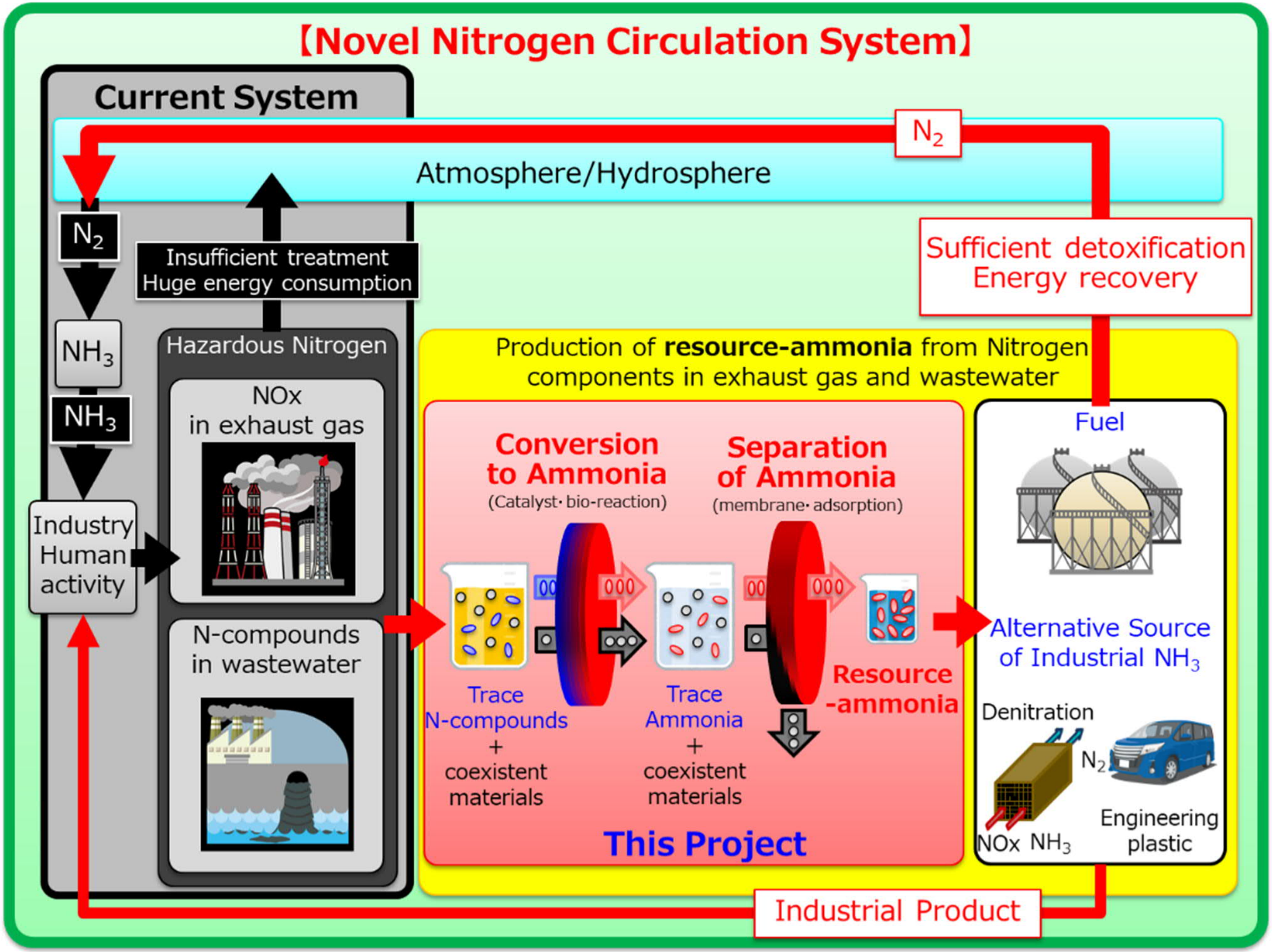
(b)Current status and target for anthropogenic nitrogen compound emissions




Additional 100Mt-N/year reduction is necessary

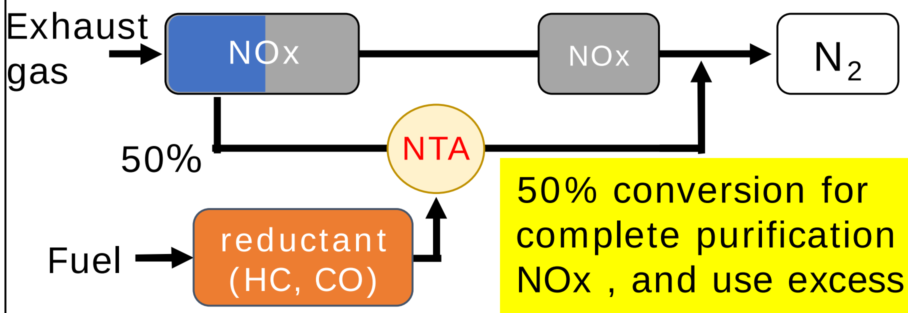
*Tsunemi et al., submitted*

# Outline of the project



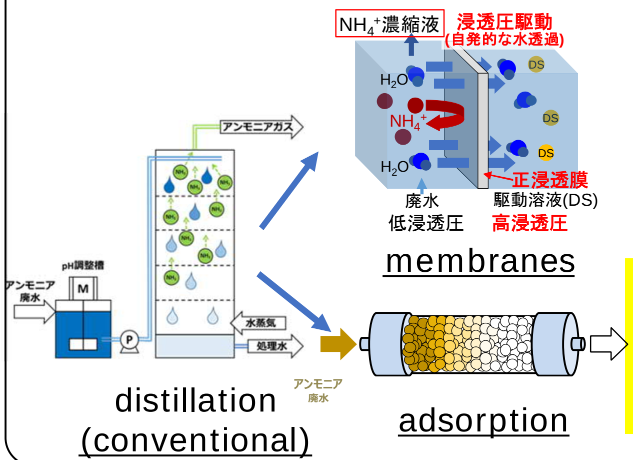
# R&D Items

## 【1. NOx to ammonia】
①concentration of NOx·$NH_3$ in gas phase
②catalyst for NOx→$NH_3$ at low temperature
③catalyst even with O2 coexistence




50% conversion for complete purification of NOx , and use excess $NH_3$ as a resource

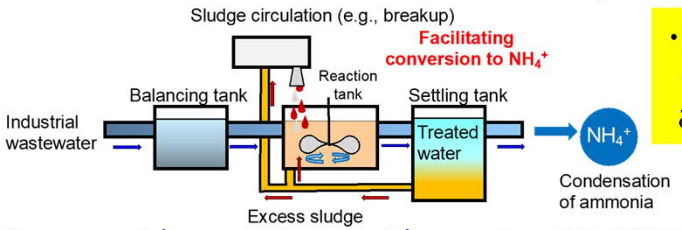
## 【2-2. ammonia recovery in water】
(1) new membrane/adsorption separation
(2) Construction of ultra energy-saving separation and concentration process




<1/100 of the energy consumption of conventional methods

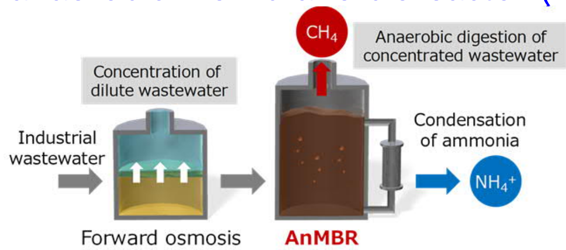
## 【2-1. conversion to $NH_3$ in wastewater】
Efficient $NH_4^+$ conversion bioprocess for various conditions

● microaerobic conversion to $NH_4^+$



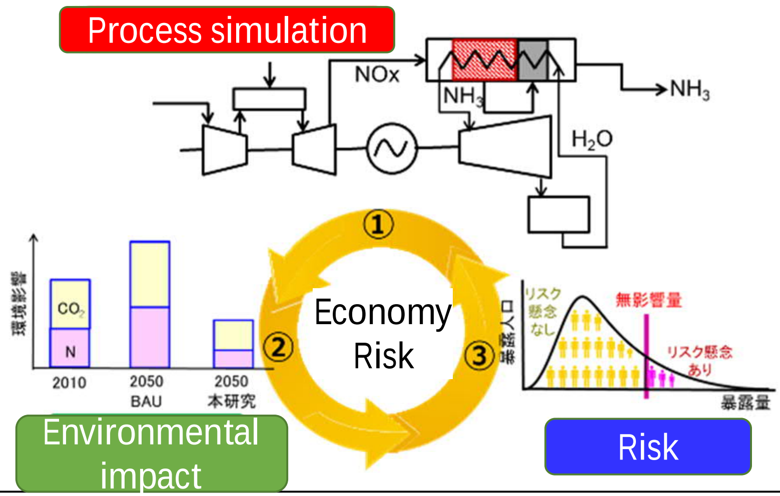

·Low $NH_4^+$ loss
·Use excess sludge as nitrogen source

● anaerobic membrane bioreactor (AnMBR) for high-$NH_4^+$




·work at high NH4-concentration
·High energy efficiency and compact size

## 【Theme 3. Process and evaluation】
1) Process design of actual equipment and pilots 2) economic and environmental impact assessment.



# Program

| Time | Theme | Speaker, Affiliation |
|---|---|---|
| 10:00 | Outline & Theme 3 | Dr. T. Kawamoto, AIST(1) |
| 10:06 | Theme 1. NOx to Ammonia | Prof. M. Ogura, Univ. Tokyo |
| 10:15 | | Prof. M. Iwamoto, Waseda Univ. |
| 10:21 | | Dr. M. Tanaka, Ube Industries, Ltd. |
| 10:24 | Theme 2-1. conversion of nitrogen compounds to $NH_4^+$ | Dr. T. Hori, AIST(2) |
| 10:28 | | Prof. A. Terada, TUAT |
| 10:34 | | Dr. R. Ohashi, Kyowa Hakko Bio Co., Ltd. |
| 10:37 | | Prof. M. Ike, Osaka Univ. |
| 10:46 | Theme. 2-2. $NH_4^+$ recycling by Separation and concentration | Prof. H. Matsuyama, Kobe Univ. |
| 10:58 | | Mr. H. Sakurai, Toyobo Co., Ltd. |
| 11:02 | | Prof. M. Higa, Yamaguchi Univ. |
| 11:07 | | Mr. S. Doi, ASTOM corporation |
| 11:10 | | Dr. T. Kawamoto, AIST(3) |
| 11:17 | | Dr. K. Kogure, Fuso Corporation |
| 11:20 | | Q&A |

A more detailed overview will be given at 14:35 in Room 1.

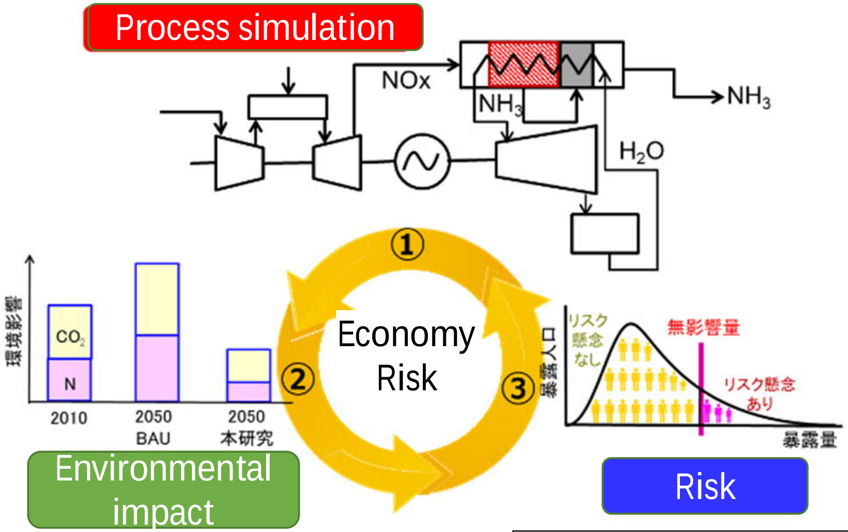
# Outline of Theme 3

- Evaluation of the effects our technologies
- Clarification the issues in the practical application of nitrogen cycle technologies.

Optimal combination of each elemental technology and constructed a practical system.

【Required technologies】
1) Management of R&D data and models
2) Estimation of various environmental impacts
3) Risk estimation of nitrogen compounds

1. Process design of practical equipment




2. Various cost evaluation (cost, $CO_2$, N emission etc.)

③RIsk assessment of implementation of new technologies

【Method】Construction of a frame for the comprehensive evaluation of the R&D

①Managing R&D data and models for nitrogen cycle technologies

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②Unique nitrogen inventory data, and development of a regional atmospheric chemical transport model applicable to local and urban scales

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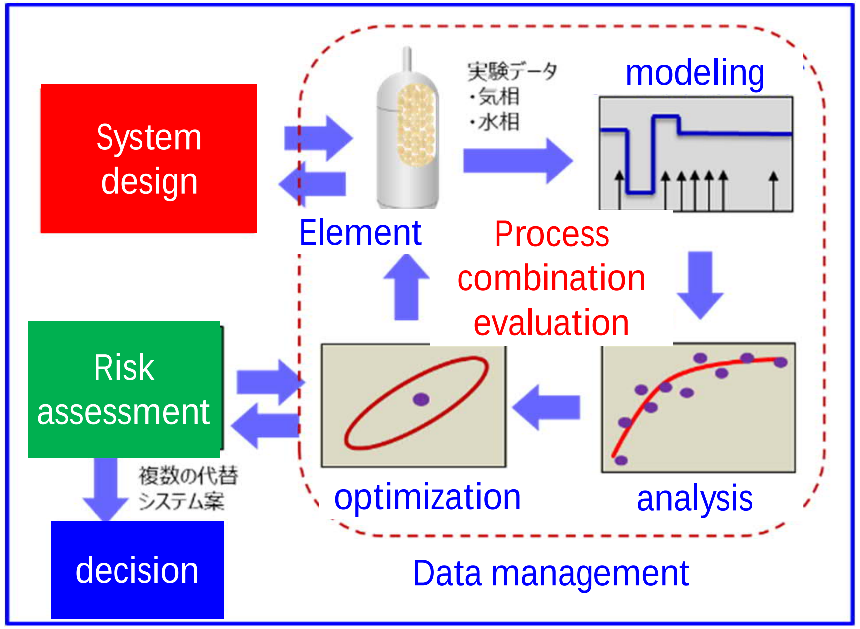
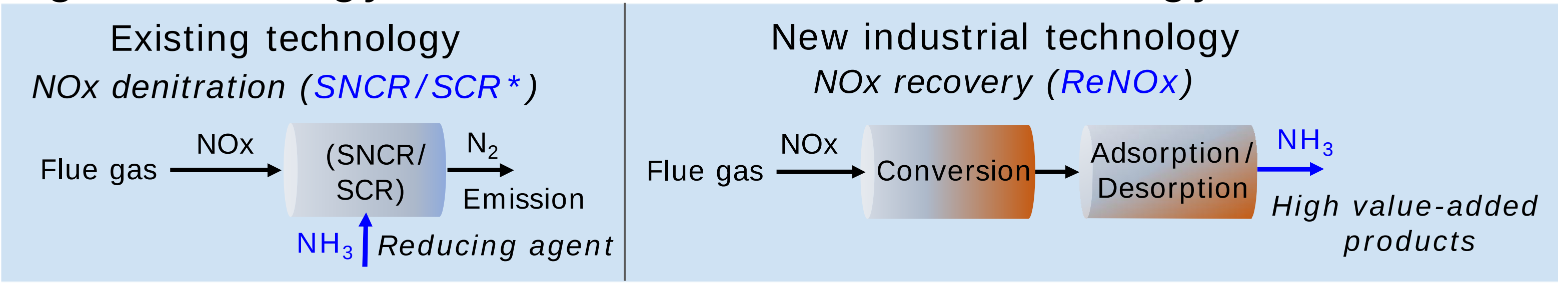


# Achievement (3) Environmental Impact Assessment of Nitrogen Cycling (AIST)

- Conduct life cycle assessment of NOx recovery, compare with existing NOx detoxification.
- The results indicated the effect that NOx recovery can reduce the environmental impacts.

## Existing Technology vs New Industrial Technology




*SNCR : selective non-catalytic reduction
SCR : selective catalytic reduction

## Life cycle assessment

Damages (LIME2、4 categories)

| | human health (DALY) | social assets (JPY) | biodiversity (EINES) | primary production (kg DW eq.) |
|---|---|---|---|---|
| SNCR | 3.64E-03 | 2.94E+04 | 1.82E-11 | 8.36E+01 |
| SCR | 1.39E-03 | 1.34E+04 | 3.92E-10 | 5.43E+01 |
| ReNOx | 2.29E-04 | 1.61E+03 | 9.85E-11 | 6.16E+00 |

Integration (LIME2)

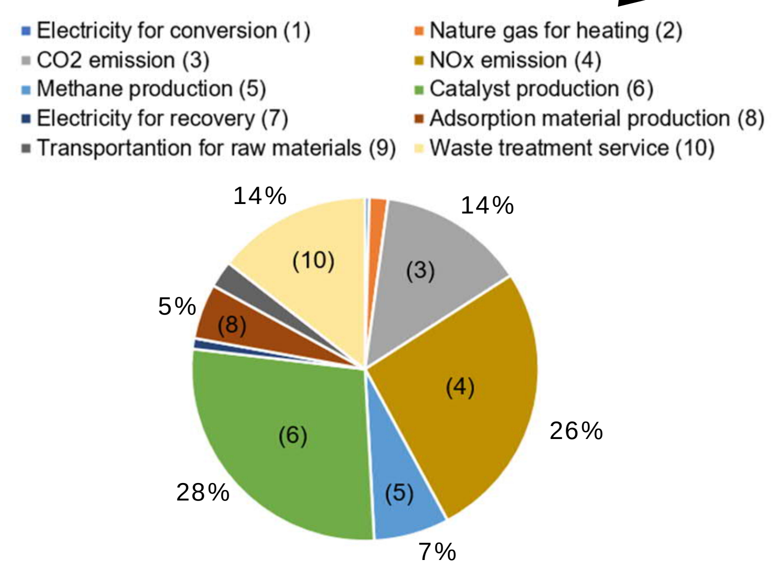
| | eco-index (JPY) |
|---|---|
| SNCR | 8.58E+04 |
| SCR | 4.19E+04 |
| ReNOx | 7.16E+03 |

Maximum / Middle / Minimum

The integration assessment revealed that the environmental impact of ReNOx is the minimum.

Driving factor analysis for ReNOx

Catalyst production & NOx emission are critical for ReNOx.




Xue *et al.*, *Sustainability*, 13(14), 7826 (2021).

# まとめ

【Background】

- Release of nitrogen compounds into the environment is one of the biggest challenges in the planetary boundary → In terms of recoverability, it is a greater risk than climate change, etc.In order to solve this issue, it is necessary to reduce emissions from industry and daily life by 100 million tons.

【 Objective of the research and development 】

- Development of technology to reduce emissions of nitrogen compounds by 100 million tons in 2050.

【 Development items 】

- Technology to convert NOx in exhaust gas into ammonia for detoxification and conversion to resources
- Technology to convert nitrogen compounds in wastewater into ammonia and convert them into resources
- Evaluation of the effectiveness of the developed technology.

【 Results (Theme 3) 】

- Conduct life cycle assessment of NOx recovery, compare with existing NOx detoxification.
- The results indicated the effect that NOx recovery can reduce the environmental impacts.

A more detailed overview will be given at 14:35 in Room 1.

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RESEARCH & DEVELOPMENT PROGRAM