Development of Refrigeration and Air-Conditioning Technologies for Practical Use of Next-Generation Low-GWP Refrigerants

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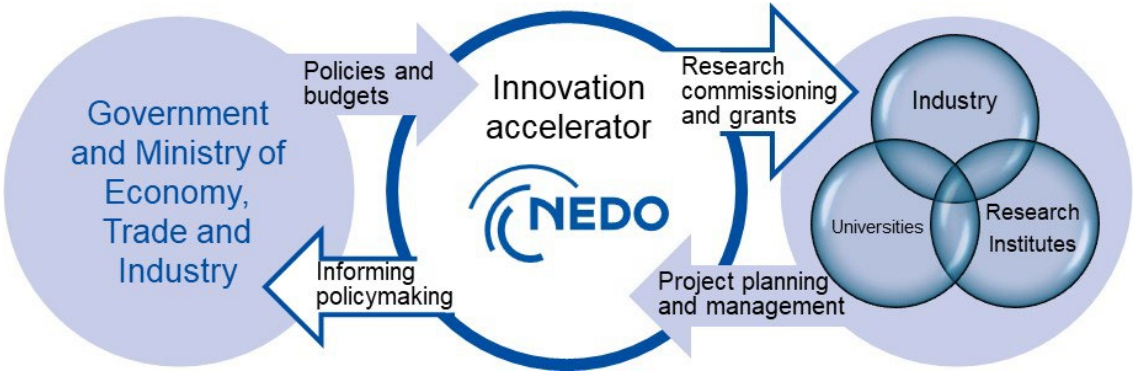
About NEDO

Missions

- Address global energy and environmental challenges
  - – Develop renewable energy and energy-saving technologies
  - – Conduct demonstration projects in Japan and overseas
- Enhance industrial technological capabilities
  - – Discover and foster promising seeds for future industries
  - – Support R&D from basic stage to commercialization



Positioning of NEDO

Roles

- National policy implementation agency in energy, environment, and industrial technology
- Conducts high-risk R&D that private companies cannot pursue alone
- Promotes collaboration among industry, academia, and government

NEDO's business fields and budget

FY2024 Initial Budget: JPY 182.8 billion

Energy Systems: JPY 52.5 billion

[Technical content]
- Power system technology
- Energy storage technologies such as batteries
- Hydrogen production, storage, and transportation technologies
- Renewable energy technology

Industrial Technology: JPY 31.6 billion

[Technical content]
- Robotics and AI technology
- IOT/electronic information technology
- Manufacturing Technology
- Materials and Nanotechnology
- Bioeconomy

Energy Conservation & Environmental: JPY 36.5 billion

[Technical content]
- Innovative energy-saving technology
- Environmentally friendly process technology
- High-efficiency coal-fired power generation technology development
- Carbon dioxide separation and capture technology
- **Fluorocarbon countermeasure technology**
- Resource sorting and metal refining technology

New Industry Creation & Seed Discovery: JPY 54.3 billion

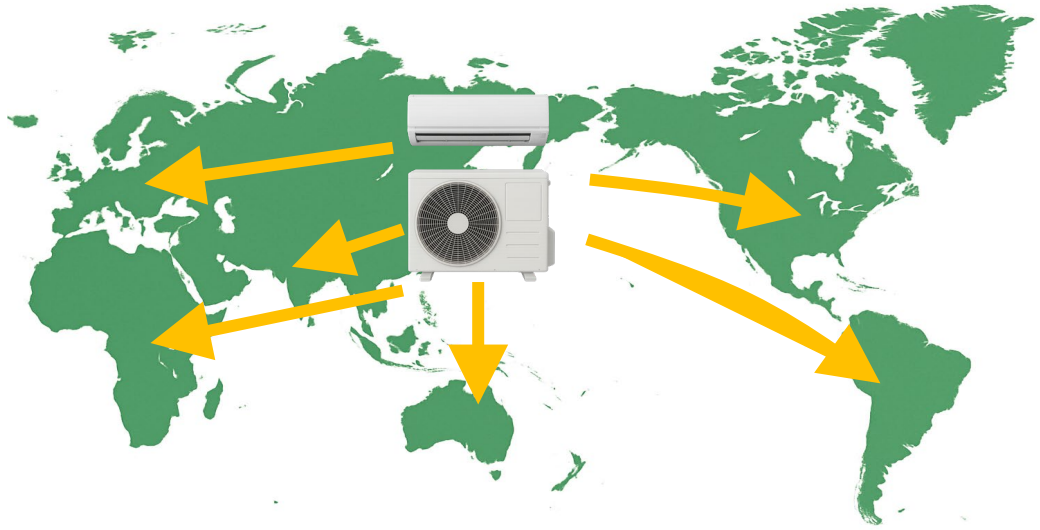
[Technical content]
- Nurturing R&D startups
- Promoting open innovation

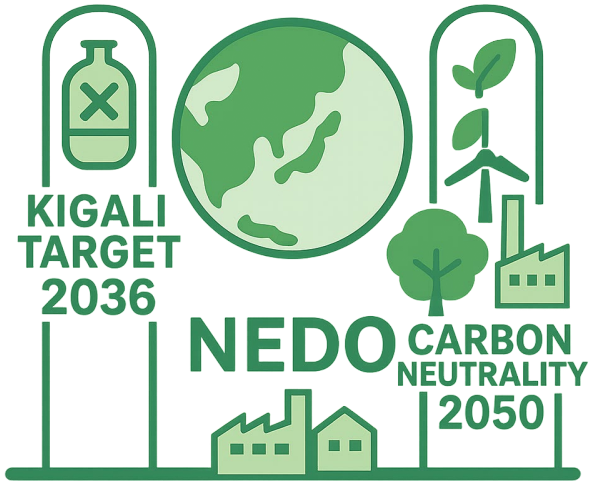
Major National Projects (additional funds):
- Green Innovation Fund: JPY2,756 billion
- Stable Supply Ensuring Fund: JPY1,940 billion
- Post-5G Infrastructure R&D: JPY1,472 billion
- Economic Security Critical Technology Program: JPY250 billion
- Moonshot Research and Development Program: JPY50.1 billion

Desired future vision and outcome

Future Vision & Outcome

- **Kigali Target**: –85% HFCs by 2036
- **Carbon Neutrality 2050**: via low-GWP refrigerants
- **Competitiveness**: Strengthen Japan's refrigerant & equipment industry



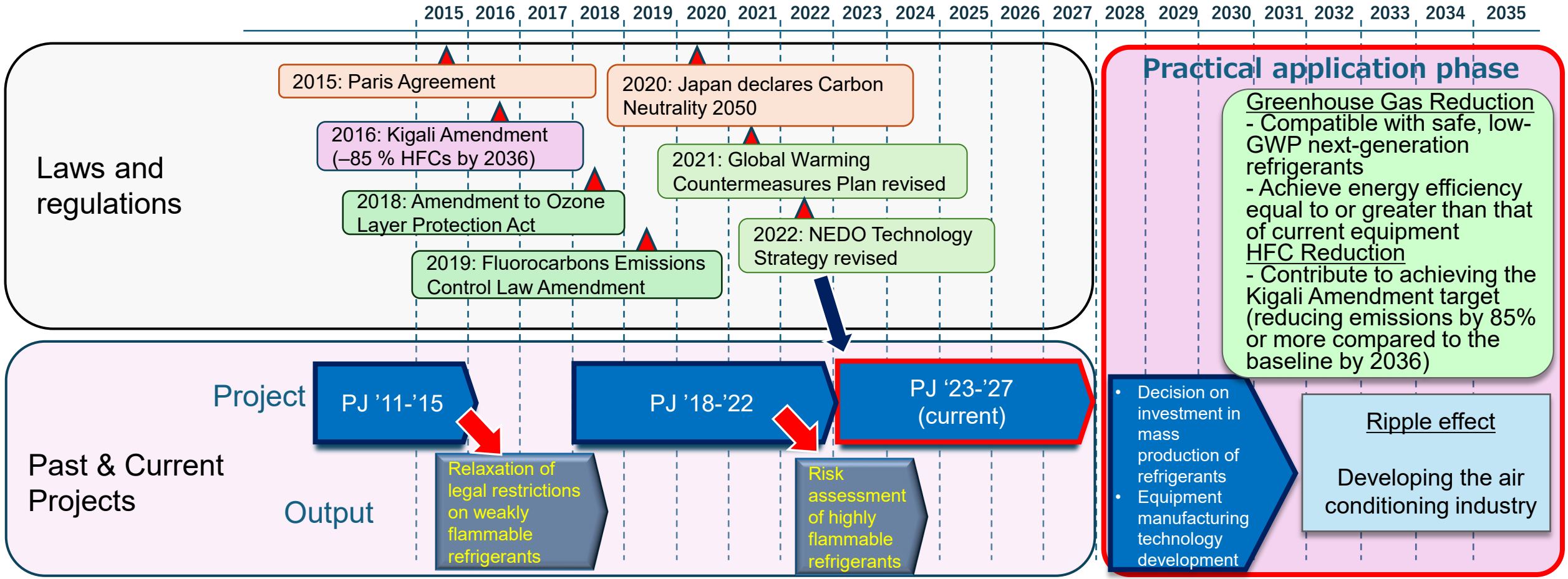


Current Situation

- Policy shift: **Ozone → Global warming mitigation**
- Adoption of **green refrigerants** accelerating
- Gaps remain in residential A/C → project focus

History of NEDO's development of fluorocarbon-related technologies

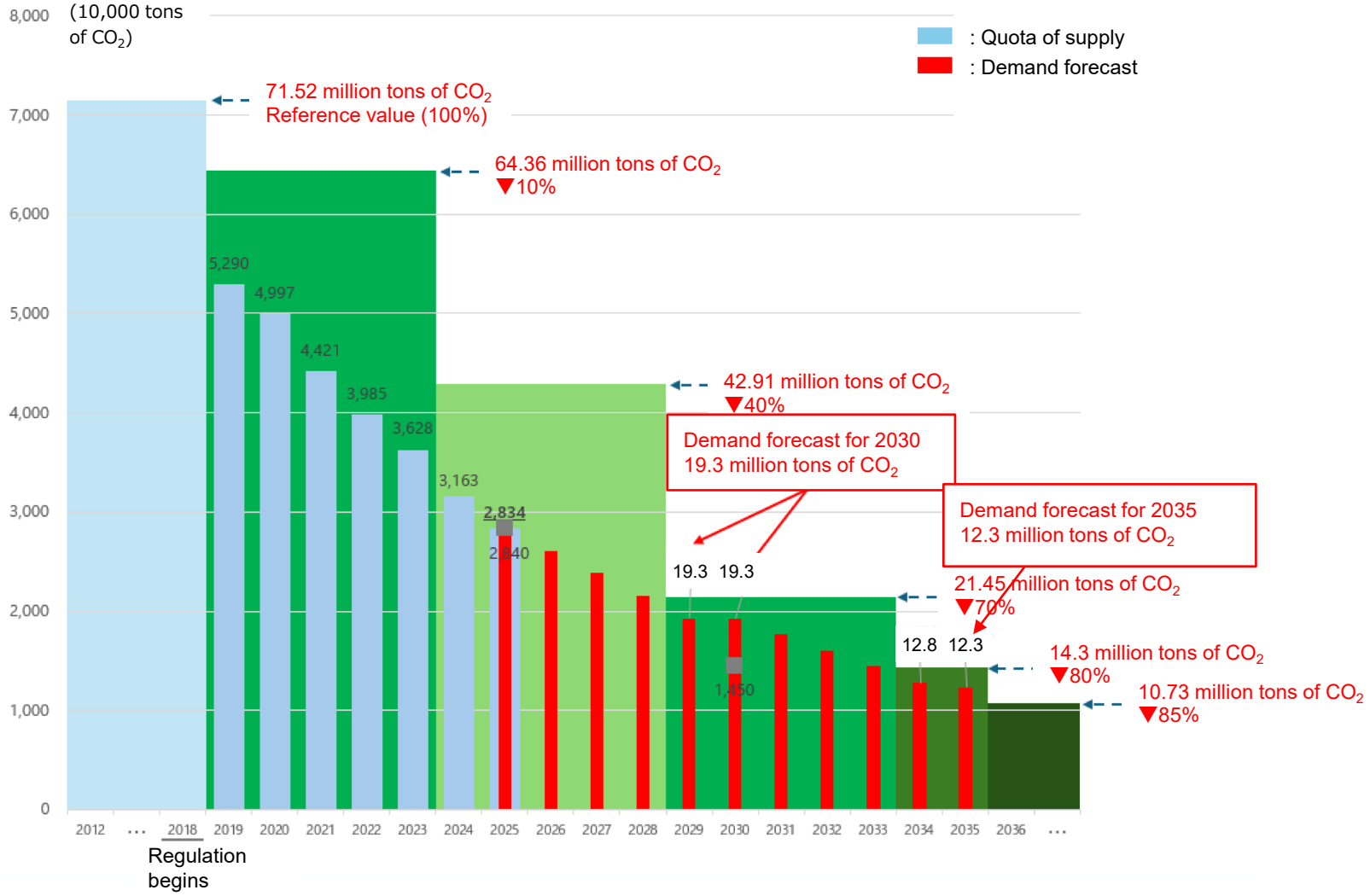
■ Policy shift from ozone protection to global warming mitigation → NEDO revised its strategy (2022) and launched a new project (2023–27)



Scenario for introducing green refrigerants and equipment through legal regulations and technological development support

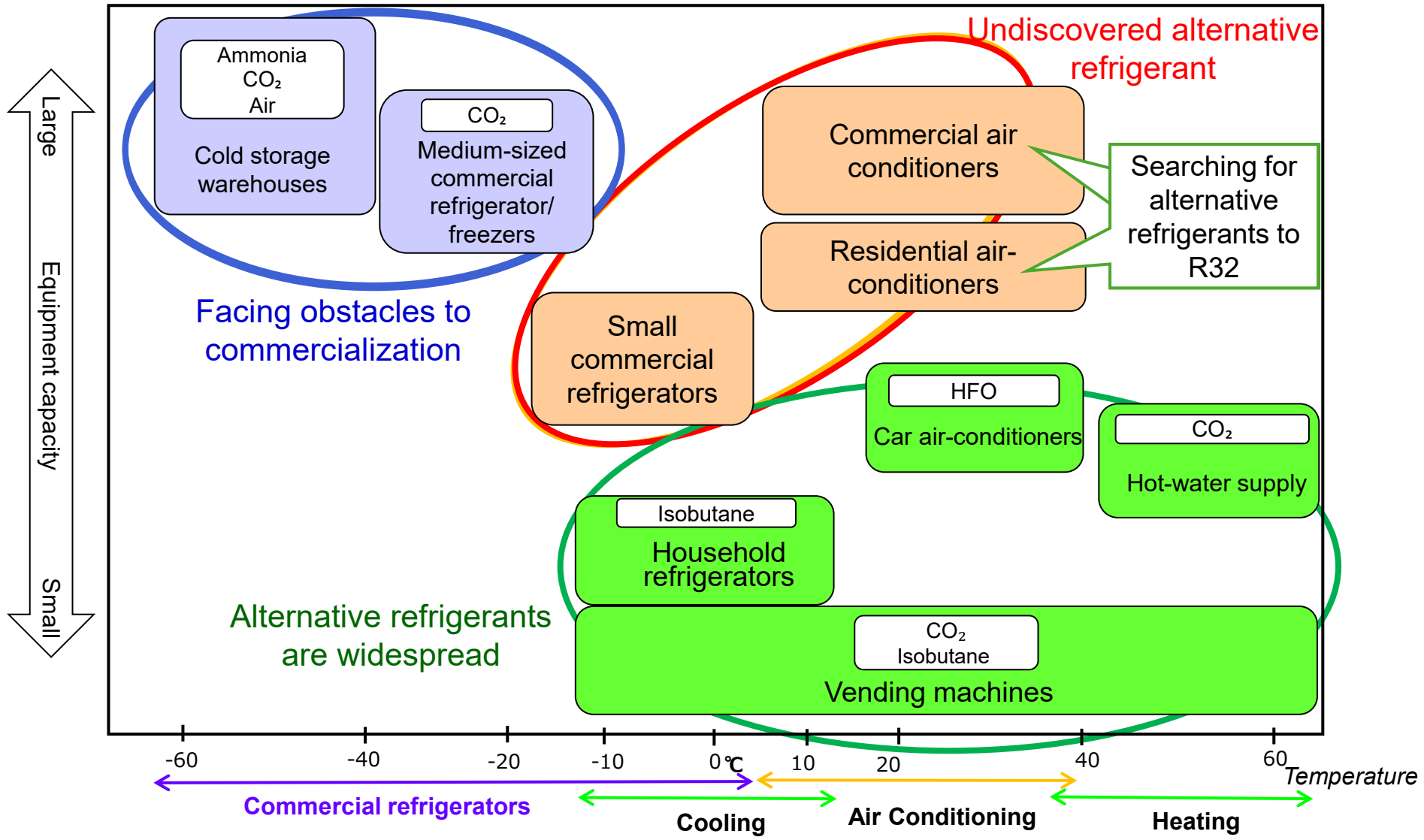
Scenario for Low-GWP Refrigerant Introduction

- Policy & Regulation
  - Revised Kigali standards applied (with ~10% reserve)
  - Shift to low-GWP refrigerants under development
- Resource Use
  - Maximize utilization of recycled refrigerants
- Demand Outlook (CO_2 equivalent)
  - 19.3 million tons for 2030
  - 12.3 million tons for 2035
- Future Expectation
  - Beyond 2034: Practical use of NEDO's low-GWP refrigerants is key



Comparison of the standards under the Kigali Amendment to the Montreal Protocol and the Fluorocarbon Demand Outlook (Document from the Fluorocarbons Countermeasures Working Group of the Industrial Structure Council, Ministry of Economy, Trade and Industry, March 25, 2025)

Development status of low-GWP refrigerant by application



Overview of the NEDO project

Purpose

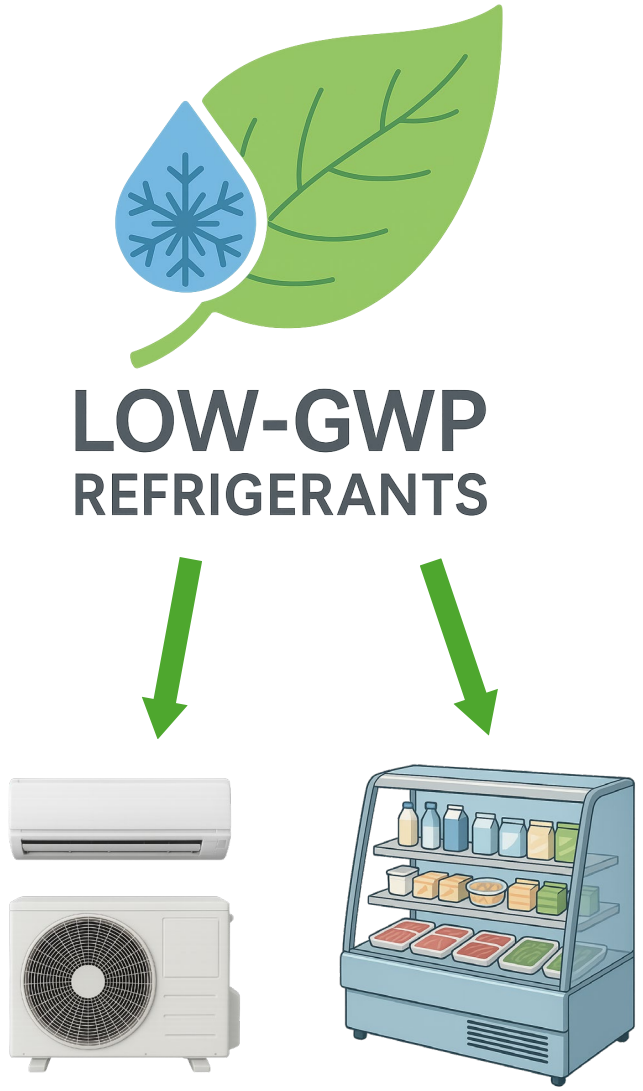
1. Focus on residential A/C and equipment without defined next-gen refrigerants
2. Lay foundation for **early commercialization** of low-GWP refrigerants & systems

Period & budget

- FY2023–2027 (5 years)
- ~JPY 500 million / year

Implementation items

1. Thermal property, safety & environmental assessment
2. Development of component technologies
3. System performance evaluation
4. Development of condensing units with low-GWP refrigerants



Low-GWP refrigerant developed in NEDO project

HFO-1123 (AGC Inc.)

R1132(E) (Daikin Industries)

1. Common Features

- GWP < 1, ODP = 0
- Suitable for A/C and automotive use

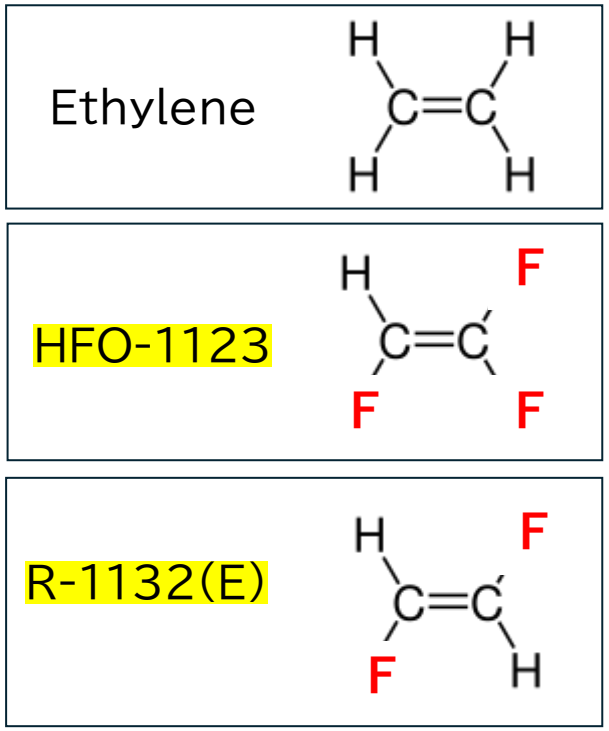
2. Common Issue

- Risk of self-decomposition reaction in compressor (high T/P)

3. Selection Criteria for Mixtures

- Low GWP (< 150, ideally < 10)
- Low flammability and toxicity ⇒ A2L
- Suppressed self-decomposition
- High energy efficiency in A/C use
- Material & lubricant compatibility
- Use of a physical properties database is preferred

⇒ Search for refrigerant mixtures



Self-decomposition reaction

HFO-1123

$$CF_2 = CHF \rightarrow \frac{1}{2}CF_4 + \frac{3}{2}C + HF + 250\ \mathrm{kJ/mol}$$

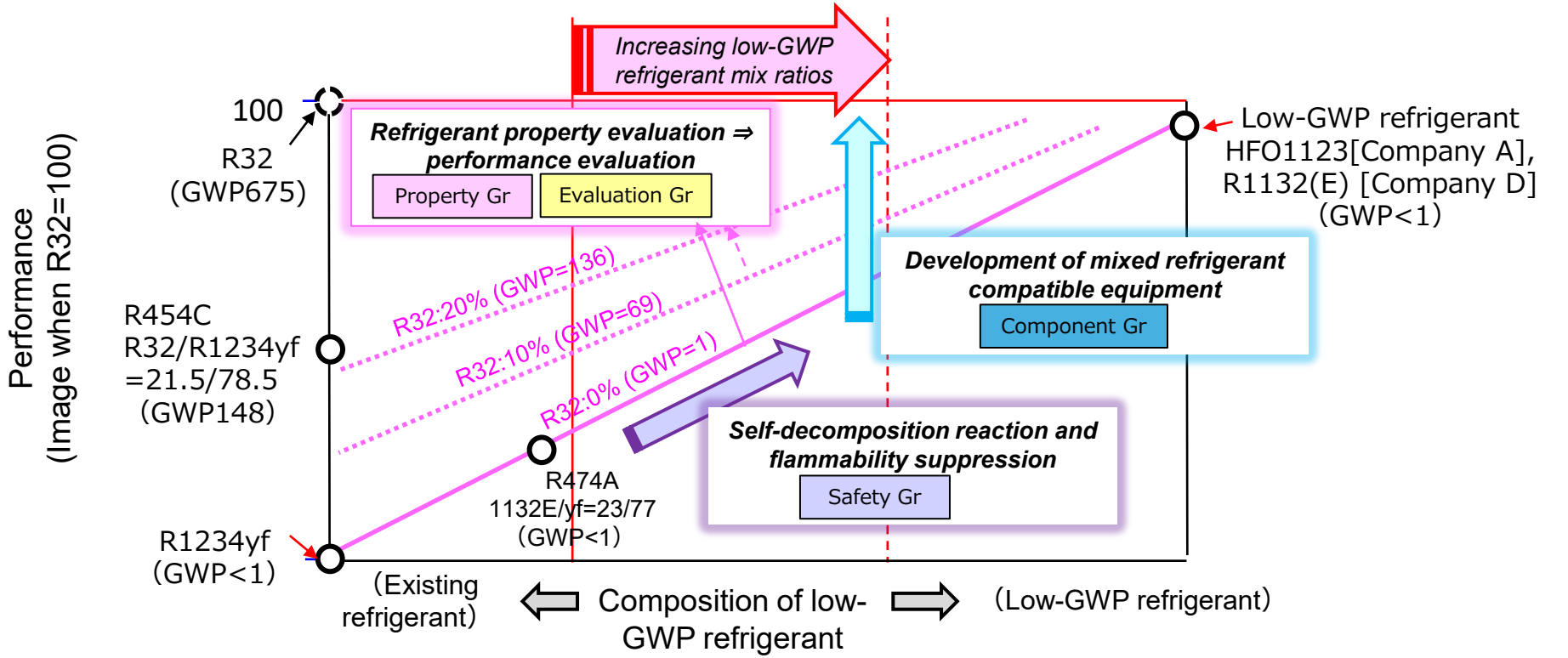
R-1132(E)

$$CHF = CHF \rightarrow 2C + 2HF + 248\ \mathrm{kJ/mol}$$

Research and Development Goals

Goals

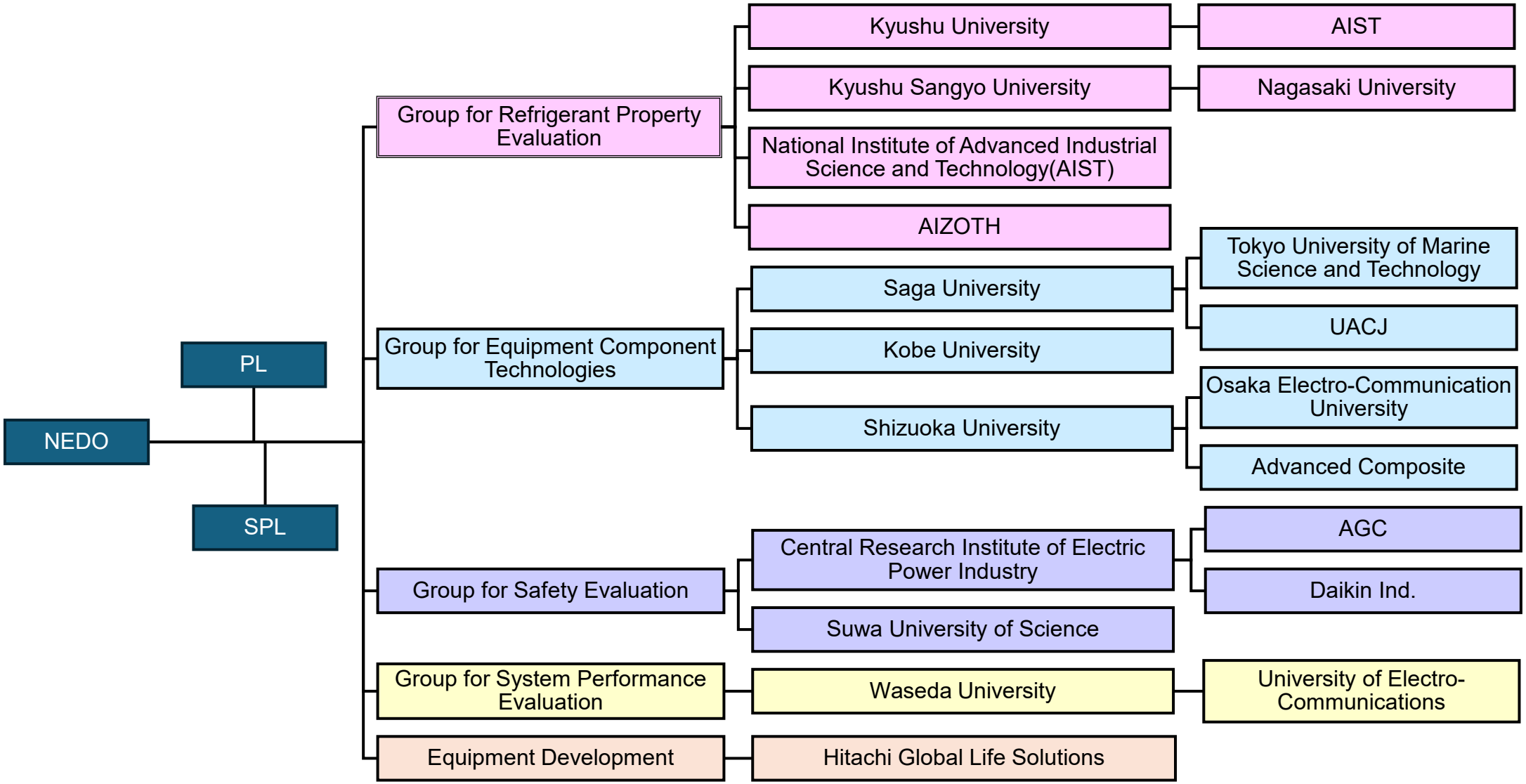
- Increase low-GWP refrigerant ratio for improving the performance
- Achieve performance equal to R32 systems
- Address safety (self-decomposition, flammability)



LOW-GWP REFRIGERANTS

Image of the direction of this project and the positioning of each research group

Project Structure

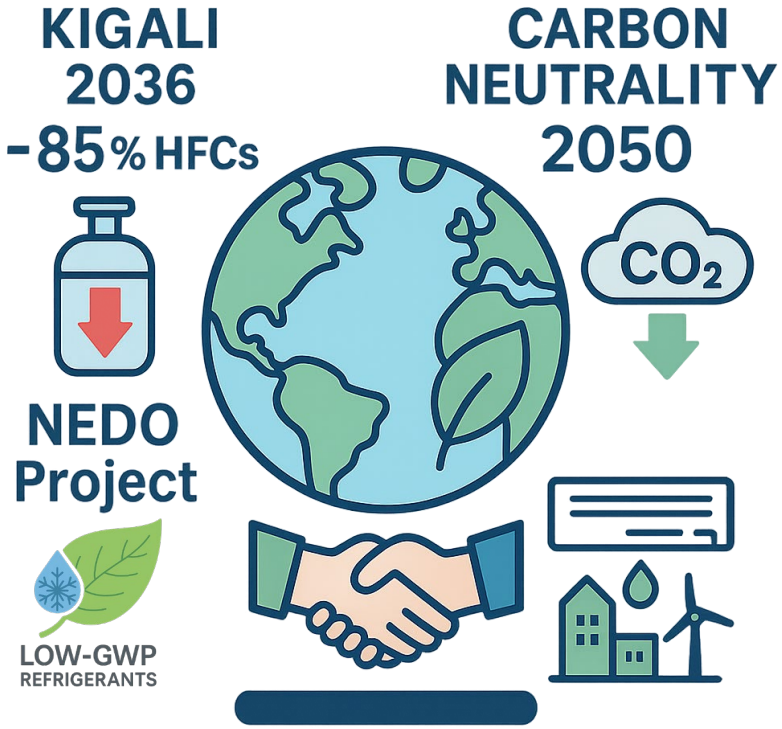


Project implementation theme and content

Theme	Contractor	Contents
■ Commissioned project (Development and evaluation of low GWP refrigerant mixtures suitable for residential air conditioning, etc.)		
Group for Refrigerant Property Evaluation	Kyushu University	Acquisition of thermophysical property data and narrowing down of candidate refrigerants
	Kyushu Sangyo University	Development of equation of state and mixture model, performance evaluation using refrigeration cycle model test equipment, analysis of losses in cycle elements
	AIST	Safety characteristics evaluation, especially regarding flammability
	AIZOTH	LCCP evaluation method for air conditioning equipment using low-GWP refrigerants and AI analysis
Group for Equipment Component Technologies	Saga University	[Heat exchangers] Elemental technologies for suppressing heat transfer degradation, technologies for suppressing heat transfer degradation and their application to heat exchangers
	Kobe University	[Heat exchangers] Clarification of heat flow mechanisms and research and development of heat transfer enhancement technologies
	Shizuoka University	[Compressor] Elucidation of refrigerant dissolution behavior and compatibility evaluation of refrigeration oil, elucidation of compression characteristics, elucidation of friction, wear, and lubrication characteristics, development of metal matrix composite materials suitable for compressor parts
Group for Safety Evaluation	Central Research Institute of Electric Power Industry	Research into the safety of HFO refrigerant self-decomposition reactions, development of self-decomposition reaction evaluation methods, and research into HFO-1123 and R1132(E) mixed refrigerants
	Suwa University of Science	Identifying factors that induce self-decomposition reactions in compressors and developing energy evaluation methods
Group for System Performance Evaluation	Waseda University	Development of system evaluation methods and AI optimization algorithms for refrigeration cycle simulators
■ Subsidized Project (Development of Equipment Using Low-GWP Refrigerants)		
Equipment Development	Hitachi Global Life Solutions	Development of a condensing unit using low-GWP refrigerants

Conclusions

1. Contribute to Kigali target (–85% HFCs by 2036) and Paris Agreement goals
2. By 2030+, NEDO's low-GWP refrigerants will enter practical use
3. Support carbon neutrality 2050 through safe, efficient refrigerant technology
4. Collaboration & information sharing with stakeholders is essential



→ **NEDO drives the global transition toward safe, low-GWP refrigerants.**